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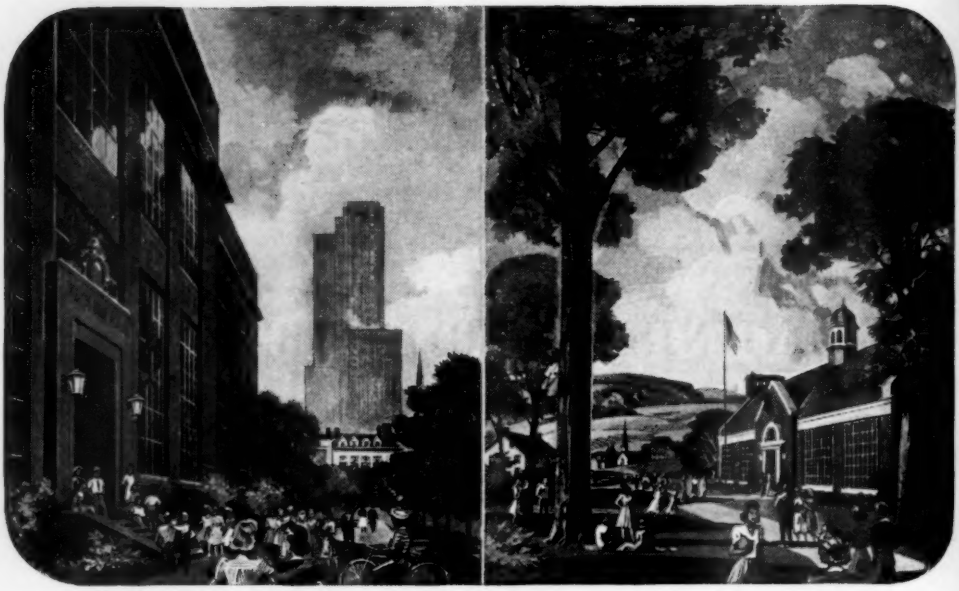

From the largest city to the smallest town high school seniors have equal opportunity in the Science Talent Search

The Third Annual Science Talent Search has now begun. Sponsored by Westinghouse and conducted by Science Clubs of America, this competition is open to seniors in every high school and preparatory school in the United States. Scholarships ranging from $100 to $2400 will be awarded.

Outstanding students in your graduating class deserve the opportunity to compete for these scholarships. Formal science courses are extremely helpful, but not necessary. Winners are selected solely on the basis of their aptitude for creative achievement in science.

Contestants are required to take a science aptitude examination and to write a 1,000 word essay. The essay subject this year is "My Scientific Project." The essay should tell what the student is doing or plans to do in the way of experimentation or other research activity.

Records of those who received Westinghouse Science Scholarships or honorable mention in 1942 and 1943 show that winners come from all parts of the country, from private preparatory schools and public high schools, from graduating classes of less than 20 students to more than 1,000. There is equal opportunity for every senior who has the requisite ability.

For full information concerning the Third Annual Science Talent Search, write to Science Service, 1719 N. Street, N.W., Washington (6), D. C., or to School Service, Westinghouse Electric & Manufacturing Company, 306 Fourth Ave., P. O. Box 1017, Pittsburgh (30), Pa.

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SCHOOL SCIENCE
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MATHEMATICS

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BIOLOGY FOR WARTIME

CHARLOTTE L. GRANT
Arsenal Technical Schools, Indianapolis, Indiana

Biology contributes essential knowledge and useful skills for wartime living. The following program presents some projects, reports and discussions adapted to Biology teaching in a city high school.

Health

1. Physical fitness activities (indoors and out-of-doors).
2. Reports on diets, rest, use of laxatives, drugs, tobacco, and alcohol.
3. First aid demonstrations.
4. Exhibits of patent medicines.
5. Charts on diseases and their treatment (particularly epidemic and tropical diseases).
6. Book and pamphlet reviews, such as *Microbe Hunters*, *Life of Louis Pasteur*, *Communicable Diseases*, and *Public Health Reports*.
7. Essays on what to do about health problems such as smoke-filled atmosphere, polluted water, poor housing, and a lack of inspection in restaurants.
8. Check list items on films such as *They do Come Back*, *Behind The Shadows*, and *Body Defenses Against Disease*.

Food and Nutrition

1. Food charts: sources, distribution, uses, substitutes.

2. Discussion of vitamin- and mineral-containing foods with magazine pictures to illustrate.
3. Chart of student meals for several days to a week. Second chart to show changes in meals to make a well-balanced diet.
4. Scrapbooks of pictures and articles on results of poor diet and vitamin deficiencies; labels of highly advertised and unusual foods; and labels and advertisements of patent medicines for getting rid of excess fat.
5. Studies and experiments on food decay, food storage, food preservation and food dehydration.
6. Essays on "How to Maintain Health Through Eating Proper Foods" and "Winning the War with Foods."
7. Debate on "Farm Work versus War Work."
8. Check lists of items in films on *Ever Since Eden* (H. J. Heinz), *Yesterday, Today and Tomorrow* (H. J. Heinz), *Vim, Vigor and Vitamins*, *Hidden Hunger* and *Foods and Nutrition*.

Physiology of Human Organism

I. Discussion and reports on:
   1. Digestion: influence of war environment, new foods, and disease.
   2. Circulation: blood types, blood banks, and blood preservation.
   3. Respiration: pressure changes and their effects, altitude sickness, artificial respiration, respiratory diseases.
   4. Glandular activity: deficiencies in glands and their treatment; importance of glands in normal body functioning.
   5. Nervous system: shock, war fatigue, industrial changes (day and night shifts), and the importance of normal sense organs (eyes and ears).

II. Experiments on circulation, sense organs, artificial respiration, and microscopic examination of blood cells and disease organisms.

III. Check list of items on films such as *Digestion of Foods*, *Nervous System*, and *Functions of the Kidneys*.

Reproduction and Improvement of Plants and Animals

1. Discussion of production of better plants and animals

through breeding and what this means to us today.

2. Panel or roundtable on eugenics and its meaning to human race.
3. Charts on the life span of a human being from birth to death with ages, characteristics and some problems of each stage.
4. Essays and individual conferences on "Problems of the Adolescent."
5. Construction of family tree by students willing to devote time to looking up family histories. Several used photographs of the more recent members of the family.
6. Lists of hereditary traits and pictorial presentation of how these follow Mendel's law of heredity. Film on *Heredity*.
7. Debate on "Are Good and Bad Morals Inherited."
8. Committee reports on the races of people, where they come from, where they now live and changes among them.

Conservation

1. Reports on soil, forest, water, wildlife and mineral resources; depletion and shortages in these; practices in conservation.
2. Exhibits on "Man's Relation to Plant and Animal Communities"—waste, lumbering, agriculture, fire, etc.
3. Map-making of national and state forests and parks.
4. Visits to city parks and school preserve to study plant and animal communities.
5. Individual studies and reports on lumber, its sources, flow into the state, uses, and substitution for metals.
6. Visit to State Conservation Department to secure literature on state properties; visit to State Fish Hatchery and to nearby State Forest.
7. Exhibits (by natural products and photographs) of fiber plants, medicinal plants and animals, rubber, sugar plants, beverage plants, spices, plant oils and gums and substitutes for these.
8. Committee visits and reports on:
   a. Public Health Measures
   b. Safety in Traffic, Industry and at Home

c. Public Welfare—Agencies and activities.
d. Housing in the community.

9. Panel on "Conservation of Fuel, Clothing, Food and House Facilities."
10. Making a Victory Garden at school or home.
11. Check list of items on films such as *Conservation of Our Natural Resources*, *Vanishing Herds*, *Harvest for Tomorrow*, *Irrigation Farming*, and *Trees for Tomorrow*.

Vocations and Avocations

1. Check-lists of both indicating best-liked and least-liked.
2. Photographs of hobbies.
3. Reports on hobbies with demonstrations.
4. Requests for government articles on forestry, farming, medicine, etc.
5. Reports on "Careers" from Institute of Research, Chicago.
6. Essays on "My Hobby" or "My Leisure-time Activity" or "Plans for my Life Work."
7. Check list of items on films such as *Gardening*, *Science and Agriculture*, and *Re-creation*.

SCIENTIFIC ENGINEERING IN DESIGNING AND PRODUCTION MADE UNPARALLELED SHIPBUILDING ACHIEVEMENT POSSIBLE

Over 2,000 ocean-going vessels built under Maritime Commission contract since Pearl Harbor is the record celebrated on Monday, Sept. 27, two years from the day the first Liberty ship, the Patrick Henry, slid into the water. Cooperation between scientists, engineers and production men made this unparalleled achievement possible.

The 2,000th vessel since Pearl Harbor is a standard tanker built at the Kaiser shipyard at Portland, Ore. It was delivered with steam up on Sept. 11, and was placed in service immediately in the tanker fleet.

The Oregon Shipbuilding Corporation of Portland, two days later, became a member of the Maritime 250 Club when it sent into service a Liberty ship only 23 days from the laying of its keel. Another Kaiser yard was the first in this club when the Richmond, Calif., plant delivered its 250th vessel on July 19, 1943.

Liberty ships are not named for living persons. They are named to honor outstanding American men and women who accomplished work of nation-wide value in the fields of arts, letters and science. The Dwight W. Morrow was launched in Florida on Sept. 19, named in honor of the notable lawyer, banker, diplomat, United States Senator, and sponsor of science as a member of the Board of Trustees of the Smithsonian Institution.

DETERMINATION OF LATITUDE AND LONGITUDE

NORMA SLEIGHT
New Trier Township High School, Winnetka, Illinois

It is becoming increasingly important for more and more people to have some knowledge of how to determine a position on the earth without benefit of familiar land marks,—say, in mid-ocean. By the term position is meant latitude and longitude. The real navigator is equipped with various charts and instruments to enable him to find his position under all types of weather conditions. Some of these methods are so simple that they can be understood with very little study and mathematical background.

The sun and its planets are a small system as compared with our distances from the stars. So in Figure 1, the ellipse, depicting

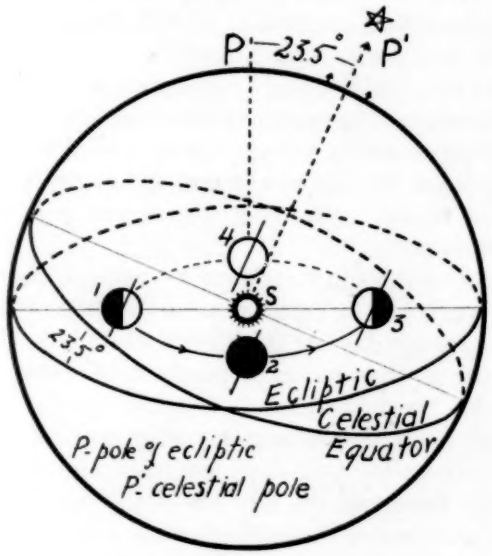

FIG. 1. The celestial sphere.

the path of the earth about the sun, S, either should shrink to practically nothing, or the outside sphere, the celestial sphere, expand right off the page. If we look at the sky on a clear night, we are apparently at the center of a large dark sphere studded with stars; we are on the inside looking out. By observation one finds that these stars maintain the same position relative to each other night after night and if time permitted during some one

night, they would be observed to rise in the east and set in the west just as the sun does. The whole sky pivots about one fixed star, Polaris, often referred to as the north star or pole star. If the plane of the earth's equator is extended into the heavens, it determines what is known as the celestial equator. The celestial equator makes an angle of 23.5° with the ecliptic. Thus the celestial pole and the pole of the ecliptic are 23.5° apart in the celestial sphere. Lest one think that the stars all fall on the surface of one great sphere, we hasten to announce that they are at varying distances from us, but their angular distances remain constant, thus giving the impression of a great sphere. The regularity of angular distances helps the navigator to fix his position.

Let us get down to earth now and take up the matter of latitude. This will be discussed as applied to the northern hemisphere only.

The most common instrument used in measuring latitude is the sextant which was invented in 1730 in Philadelphia and has been used by navigators and explorers ever since. The sextant is designed to measure the angle subtended between two objects with the observer at the vertex of the angle. It can measure an angle in any plane and is equipped with a level so that it is not necessary to sight the horizon to find the angle of elevation of the sun. It can be used on moving objects, and thus it fills a need the transit does not.

The altitude of the sun is its angular distance above the horizon. High noon is the instant when the altitude of the sun is at its maximum for the day. At this time the sun is on the meridian for that position, thus our expressions A.M. (ante meridiem), M., and P.M. (post meridiem). Shadows are at a minimum length at high noon. A local watch cannot be used to determine high noon because local time seldom coincides with sun time. To catch high noon and the altitude of the sun, hold a sextant in a vertical plane using the horizon or the level, then line up the sun. Do this a little before noon. Follow the sun as the angle of elevation increases and at the moment it starts to decrease, record the reading. But this is not the latitude yet. Observe Figure 2A. We desire the latitude of point P. $\angle a$ is the altitude of the sun. $\angle k$ is the measure of the latitude. All we need to do is to establish a relation between $\angle k$ and $\angle a$ to determine $\angle k$. At the equinoxes $\angle k = \angle b$ because the sun's rays are parallel and $\angle b = 90° - \angle a$; so $\angle k = 90° - \angle a$. In Figure 2B, $\angle d$ is the declination of the sun (angular distance of the sun's rays from

the celestial equator). This declination varies from $+23.5°$, north (summer solstice) to $-23.5°$, south (winter solstice). The Nautical or World Almanac has a list of the days of the year with the declination of the sun for each day. When graphed, these figures present a picture like Figure 3 where one cycle has been

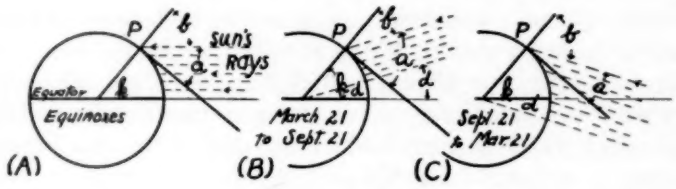

FIG. 2. Determination of the latitude of a place.

drawn. It is obvious from Figure 2B that, knowing the declination for a given day of the year, $\angle k = 90° - \angle a + \angle d$, d being negative from September 21 to March 21. The altitude of the sun decreases toward the north for a given day and from the summer solstice to the winter solstice for a given position. So supplied with the date, a clear day, a sextant, and an almanac, it is possible to determine the latitude quite easily. For example, on May 21, 1937, the declination of the sun was $20°\ 12.0'$. The

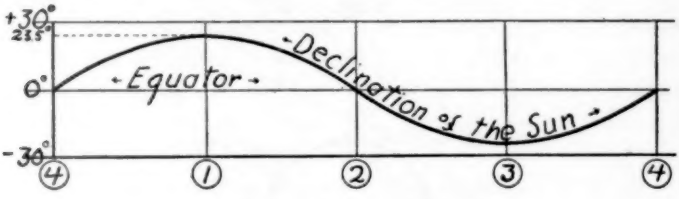

FIG. 3. The cycle of declination.

altitude of the sun was found to be $78°\ 3.2'$. Find the latitude of the observer.

$$\angle k = 90° - 78°3.2' + 20°12.0'$$

$$\angle k = 32°8.8'.$$

If the latitude and the altitude of the sun are known, the declination can be figured for that day also. It must lie between $+23.5°$ and $-23.5°$.

There are slight errors which must be taken into account by the careful observer. (1) When shooting the sun, the center cannot be determined readily. So find the lowest point. The sun

subtends an angle of 32′ with us here on earth. So add 16′ to the observed altitude because all distances, angular or linear, refer to the center of heavenly bodies. (2) Refraction. Error here is caused by the bending of the sun's rays by the earth's atmosphere. This is negligible except when the rays are nearly tangent to the earth as at sunrise or sunset. (3) Parallax. This error is introduced by making observations from the surface of the earth instead of from its center. When the sun is directly overhead, this error is zero. For distant bodies it is negligible. There are tables with combined corrections for semi-diameter, refraction, and parallax. (4) Dip. This is the error caused by the observer not being at sea level when the altitude of the sun is read, using the horizon. A correction can be made or a sextant with a level can be used to avoid this error.

To find the latitude at night, find the pole star using the dipper. See Figure 4. At present this is about a degree, plus, off the

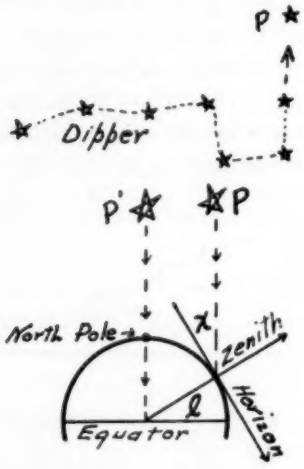

FIG. 4. Finding the latitude at night.

celestial pole. A sextant will measure $\angle x$. This is the latitude of the observer. The pole star is about 50 light years away, which reduces the earth to practically a point by comparison, therefore P' and P are essentially the same point. There are slight corrections to be made for very accurate readings taken north of 40°. Unfortunately the globe is oblate, flattened a bit at the poles because the earth has revolved so long and so hard about its axis. The equatorial radius is 3,963 miles and the polar radius 13 miles less. Even the poles wander from their mean position nearly 30

feet; consequently the equator shifts, causing a slight change in latitude for a given position. But these small irregularities need not concern us here.

Longitude! This is the angular distance of a position east or west of the prime meridian. The chronometer is the instrument in use for determining longitude and is nothing more than a very accurate clock. It is set at Greenwich mean time (G.M.T.) always; 1/24 of $360° = 15°$, hence west of the prime meridian, the chronometer will read 1 o'clock at high noon. If it reads 3 o'clock at high noon, the position is 45° west longitude. High noon is determined in the same manner as for latitude and a true north-south line can be seen by observing the direction of the shadow then. This is the shortest shadow for the day. Determination of a true north direction is done more easily with a gyro compass. This instrument will always swing around to have its axis in the same plane with the earth's axis (due to the earth's rotation) so points north-south. The magnetic compass is practical for rough work only because the north magnetic pole does not coincide with the north geographic pole. Problem. On a given day at high noon, the chronometer reads 2 hrs. 45 min. G.M.T. The altitude of the sun is 82° 23.4′. The almanac gives the declination of the sun for that day as −5° 2.9′. Find the latitude and longitude of the observer.

Finding latitudes and longitudes at various times of day and night is a more difficult task. Suffice it to say, that the heavens have been charted, the surface of the earth has been mapped, so the position of the sun or stars in the sky as seen from a certain location at a definite time can be calculated. Conversely, if the position of a star is reckoned, the corresponding place on the earth can be calculated. Celestial mechanics is so reliable that eclipses recorded by the Chinese hundreds of years ago have been checked mathematically and prediction of eclipses is common practice now.

It might be assumed from the foregoing discussions that the navigator must depend upon the existence of clear weather. If clouds are dense, he uses dead reckoning. This is the art of finding a geographical position at any moment and is deduced from the direction and amount of the ship's progress from the point of departure whose latitude and longitude are known. The navigator simplifies his reckoning by the adoption of the geographical (nautical) mile. One minute on the equator or a meridian is 1.15 statute miles but is defined as one geographical mile. Hence

$1° = 60$ geographical miles on any great circle of the earth.

It will be of interest to study a problem or two the navigator must meet.

Problem 1. A navigator wishes to sail from a point with latitude 33°N., longitude 117°W. to a location 35°N., 120°W. In

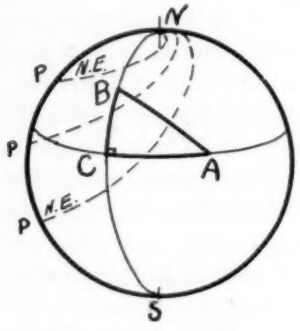

FIG. 5. A rhumb line.

what direction must he set his course? See Figure 5. Let A be the embarking point and B the desired destination. Take a point C with the latitude of A and the longitude of B. Line CA is an east-west line and line BC is a north-south line. Since we are dealing with such a small portion of the globe, triangle ABC can be solved as a plane right triangle with C the right angle.

$$BC = 2° = 120 \text{ geographical miles}$$

$$AC = 3° \text{ at } 33°\text{N.} = 3 \times 60 \times \cos 33°.$$

Hence,

$$AC = .8387 \times 180 = 150.966 \text{ geographical miles}$$

$$\cot A = AC/BC = 1.258$$

$$\angle A = 38°28'.$$

Therefore our navigator should set his course at 38° 28′ north of west. Note, a point could have been chosen originally with the longitude of A and the latitude of B.

Problem 2. A ship located at latitude 33°N., longitude 64°W. sails 200 miles (geographical) in a direction 30° north of west. Calculate the terminal position. In this type problem the course direction and mileage are recorded in the ship's log book. See Figure 5. Again A and B are the initial and destination points re-

spectively. Triangle ABC is taken as plane. First, find the new latitude.

$$\sin 30° = BC/BA$$

$BC = .5 \times 200 = 100$ geographical miles, or minutes of a great circle.

$$BC = 1.7°$$

hence the *new latitude* is $33° + 1.7° = 34.7°$N. Determine the new longitude.

$$\cos 30° = AC/AB$$

$$AC = .8660 \times 200$$

$$= 173.2 \text{ miles at } 33°\text{N.}$$

But the distance in geographical miles on the parallels equals the distance in minutes (or miles) on the equator multiplied by the cosine of the latitude in degrees

$$\text{therefore } 173.2 = d \times \cos 33°$$

$$d = 206.51 \text{ minutes or } 3.4°$$

hence the new longitude is $64° + 3.4° = 67.4°$W.

Actually if a navigator were to set his course at, say, northeast, and follow it for a great distance, his path would not describe a straight line nor even a circle. It would be a spiral which increases its curvature as it approaches the north pole but would never reach it. See the dotted lines in Figure 5. Just as it is impossible to move away from this pole in a southwest direction, it is impossible to approach it going northeast. This spiral is called a rhumb line, loxodrome is the mathematical term for it. The true direction line will appear as a spiral on any type map except the Mercator map, on which it takes the form of a straight line. For this reason the Mercator map is a favorite with the navigator. On this map the meridians are vertical and equally spaced so the northeast line makes a constant angle with them, since they are parallel. The lines of latitude are horizontal and parallel also but increasingly farther apart the nearer we are to the poles. This is necessary to keep a minute of latitude equal to a minute of longitude, thus maintaining a constant slope. It must be remembered that the latitude lines vary in length per degree away from the equator but the longitude lines are all equal. The rhumb line coincides with the great circle only

when the terminal points of a course are on the equator or on a meridian. For excellent diagram of a rhumb line, see *LIFE:* Photographic Essay, pp. 57–65, August 3, 1942.

There is no limit to the amount of work that can be done on each topic of the preceding material. However, the purpose has been to keep the information non-technical, the units simple, and thus gain a comprehensive view for general educational purposes only.

Problems:

1. What is the distance in nautical miles between two points both with a longitude of 38°W. but latitudes differing by 20°?
2. How many geographical miles are there between two points both having a latitude of 38° but differing in longitude by 20°?
3. A ship is to sail from a position 42°N. to 71°W. to a position 44°N., 66°W. In what direction should the navigator set his course?
4. A ship at 52°N-latitude, 17°W-longitude sails in a direction 33° north of west for 100 miles (nautical). Find the latitude and longitude of the new position.
5. Observation indicates that the altitude of the pole star is 18°. What is the latitude of the observer?
6. If the chronometer reads 5 o'clock (G.M.T.), observation taken at high noon, what is the longitude of the observer?
7. At high noon on May 26, 1940, the altitude of the sun was observed to be 57.3°. The almanac gives the sun's declination for that day as +21.2°. What was the latitude of the observer?
8. Name a few European cities having the same latitude as Chicago.
9. Pensacola, Florida, has the same longitude as which cities in South America?
10. Light travels at the rate of 186,000 miles a second. The pole star is 50 light years away from the earth. Express in miles its distance away from the earth. If one inch were to represent the diameter of the earth, how long a line would it take to represent our distance from the pole star, using the same scale?

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GASOLINE STORAGE

Vast underground storage tanks to hold millions of gallons of aviation gasoline and other petroleum fuels are being built at coastal points and naval outposts. They are made of bombproof concrete, and lined with synthetic rubber sheets to prevent leakage and chemical action between the gasoline and the concrete.

A GLASS-TUBE METHOD OF OBSERVING THE HOME LIFE OF SOLITARY BEES AND WASPS

CARL G. HARTMAN
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Among the "Solitary" Wasps (a name that refers to the habits of the species rather than to their taxonomy) are those which Paul Griswold Howes calls "tube fillers." These wasps utilize ready-made cracks, crevices, deserted beetle burrows or the like, completing with mud as a mortar any defects of the cavity, so that in the end prey and wasp offspring may be well sealed in. In houses the wasp will adapt herself to keyholes, occupy the tubes of spools, fill cartridge shells. For the psychologist Professor J. L. March of Union College an *Ancistrocerus* (*Odynerus*) female obligingly worked in a glass tube lying on his desk, thus serving as a convenient subject for experiments on the homing instinct.

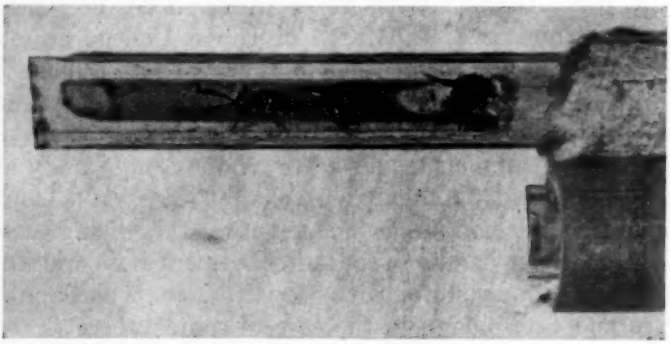
For several summers, as a vacation hobby, my family and I have studied and photographed solitary wasps at a summer camp near Bethlehem, Conn. To attract the tube-filling bees and wasps we set out bamboo tubes of convenient bore and always found them quickly stored with prey, from gnats and aphids to spiders and caterpillars; in the case of solitary bees (leaf cutters and others), the stored provender consisted of "bee-bread." The bamboo tubes have the advantage of being readily split with a pen knife for study of the development of the larvae and pupae. It was easy, too, to photograph the mother wasp as she alighted with her prey or building material and as she made the final closure of the tube with mud.

We very much desired, however, to observe the insect at work in her home. To this end the boys cut glass tubes about four inches in length and fitted them into bamboo tubes. The latter had a hole bored in one end to accommodate a two-penny nail for tacking the tubes on a convenient base—window-sill, tree trunk or the like.

Simple as it is, the plan worked from the start. One does not have to wait long for prospective wasp and bee tenants, out house hunting, to visit the tubes. Our glass-lined nests were not disdained, although an adjoining bamboo tube without glass was usually selected in preference. The glass proved too smooth

for a good footing, which was easily corrected with a narrow strip of adhesive tape.

Once the wasp has selected the tube, which is to be at once the tomb of her victims and the cradle of her offspring, she sets to work immediately. Presently she returns with a mud pellet to plug up the bottom, so that possible marauders may be kept from entering the back door. If the species is one of the Eumenidae, the egg is next laid—it is, indeed, suspended from the ceiling by a thread, an act, by the way, which we were the first to observe and capture on the motion picture film. The caterpillars are next brought in one by one until the larder is complete. If the species is one of the tribe of *Trypoxylon*, spiders are first brought in, the egg laid across the abdomen of the last large spider stored. When storage and egg laying are finished,



Male Trypoxylon mounts guard while female is out hunting spiders.

a mud partition seals the chamber, which remains closed until the emergence of the young insect of the new generation—or a cuckoo wasp, instead, if the nest had been parasitized.

While wasps or bees will not usually use an uncovered glass tube, they object very little to being exposed to the light once they are engrossed on the business in hand. The procedure, therefore, is to pull out the glass tube after the insect has entered. The private life of the insect is thus exposed to public gaze and all of the housekeeping activities observable.

By this method it has been possible not only to observe in detail and in normal sequence all of the insects' domestic activities already known by inference, but certain acts were seen, so far as we know, for the first time: egg-laying of *Trypoxylon;* egg-laying and suspension of the egg by *Odynerus;* making of

bee-bread by the bee *Alcidamea*. In all cases the manner of building the partitions proved interesting. In the case of the wasp the building material consisted of mud; the bee used leaf pulp scraped from the upper surface of green leaves.

The method is reported here because of its simplicity and its adaptability for teaching purposes. The biology class can have a lot of fun with it, in late spring or early fall. The best time, however, for wasps and bees is in the heat of summer.

A "sample" snapshot is shown in the figure.

THREE-IN-ONE TORPEDO

A three-in-one torpedo that can blast an enemy ship in several places at the same time is among the 502 patents granted this week by the U. S. Patent Office.

A central torpedo carrying two smaller auxiliary torpedoes attached to it is launched from conventional equipment now in use on ships and airplanes. As the mother torpedo nears the target, a time-controlled mechanism releases the brood of youngers which speed off to strike on either side of the main explosion. George Wise of Brooklyn, N. Y., who has received patent 2,329,736 on the weapon, gives the government permission to use his invention without payment of royalty.

MOVIES BECOME WARTIME ENGINEERING TOOL

Movies that would never be run at a theater are of dramatic interest to wartime engineers, for they measure and analyze motion and vibration in machinery.

H. D. Jackes of Wright Aeronautical Corporation, speaking before the Society of Automotive Engineers meeting, suggested three problems of the aircraft industry which might be solved by further use of high-speed motion pictures:

1. Flutter of wing and control surfaces on planes.
2. Action of wheel struts and landing mechanisms upon impact with the ground.
3. Failures and vibration of exhaust collector rings. The camera could be located in the engine compartment during flight, for example, to reveal defects in the exhaust system.

Describing uses to which high-speed motion pictures are already being put for recording valve action, oil movements, and motion studies of parts, Mr. Jackes said that film records are particularly useful because they can be easily analyzed by anyone with general engineering experience. In many research problems the movies have been found superior to strain gages, seismic vibration indicators and stroboscopes for motion analysis.

The camera is the same type used to make a "photo finish" at the races. Its value has already been recognized by several industries for studies such as the action analysis of the escapement mechanism of precision clocks and of the shutters on military aerial cameras. Movies are also used in the study of various manufacturing processes, such as blowing spun glass or the action of a high-speed weaving machine.

CONSERVATION LAWS AND ATOMIC PHYSICS*

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Scientists are not always as cautious as they should be in the pronouncements they make. Let me illustrate with three examples. According to Dalton, the man who is usually considered the founder of The Atomic Theory of Chemical Reactions, "We can as well undertake to incorporate a new planet in the solar system or to annihilate one there, as to create or destroy an atom of hydrogen." To-day we cannot accept that statement without reservations. As a second example I take Remsen, the author of a text-book in chemistry, well-known in my undergraduate days. In this book, he states the Law of the Indestructibility of Matter in these words. "Whenever a change in the composition of substances takes place, the amount of matter after the change is the same as before the change." In the light of present-day knowledge, this is an incorrect statement. My third example concerns Sir James Jeans. In his best-seller, *The Mysterious Universe*, Jeans states that "it has now been established that every atom is built up entirely of negatively charged electrons, and of positively charged particles called protons. . . . " A third time it is necessary to deny the correctness of that statement.

In my lecture this morning I propose to explain, as simply as I can, the part certain investigations in atomic physics have played in changing our views about the outstanding conservation laws of the nineteenth century. One of the laws, the conservation of matter, I have already stated in my reference to Remsen. According to views held throughout almost the whole of the nineteenth century, the second law, that of conservation of mass, was an inevitable consequence of the truth of the first, because at that time mass was considered to be the unique possession of matter. I am not suggesting that skilled scientists of the nineteenth century confused mass and matter, as some students do even in this enlightened age, but rather that the two laws were inevitably tied up together. Since mass is proportional to weight, and since quantitative chemical analysis shows no change in the weight before and after a reaction, it follows logically that there can also be no change in the total mass.

* An address given before a joint session of the Natural Science and the Mathematics and Physics Sections of the Ontario Educational Association at its Annual Meeting at Toronto, Easter 1943.

The third outstanding conservation law of the nineteenth century, which states that in all energy transactions there is no change in the total amount, stands by itself. It is a direct consequence of experiments, notably those carried out by Joule about the middle of the century. For the benefit of those of you who have noted the prominence given this law in the general science courses now being taught in the schools of Ontario, I should like to assure you, even at this early stage in my lecture, that this law still stands as unshaken as the Rock of Gibraltar.

To understand the significance of investigations in atomic physics, it is necessary to have in mind some sort of picture of the atom itself. Thousands of facts can be interpreted in terms of a model atom which consists of a *nucleus*, a positively charged kernel representing almost the total mass of the atom, surrounded by a number of *electrons*, negatively charged particles, each with a mass a trifle greater than 1/2,000 of the mass of a hydrogen atom. Normally, the positive charge on the nucleus is exactly counterbalanced by the total negative charge on the electrons. To describe fully an atom we must give not only its *Atomic Weight*, that is, a number which is proportional to its mass, but also its *Atomic Number*, or the number of positive charges on the nucleus. Indeed, since the chemical properties depend on the number of electrons and their grouping around the nucleus, and this number depends on the positive nuclear charge, the atomic number is the distinguishing label of an atom, not the atomic weight. As we shall see in a moment, the same element may have atoms with different atomic weights.

A very convenient symbol can be used to indicate both the element and its atomic weight and atomic number. For example, when we write ${}_1H^1$ we represent ordinary hydrogen, with Atomic Weight approximately 1 (the upper right figure) and Atomic Number 1 (the lower left figure). ${}_3Li^7$ represents lithium with Atomic Number 3 and Atomic Weight 7. This notation we shall use freely throughout the lecture.

If an atom loses one electron, the nucleus has one unbalanced positive charge, and we are left with a singly-charged positive *ion*. In the case of hydrogen, which in its normal state has only one electron, the ion, the nucleus itself, is given a special name, the *proton*. Sometimes two electrons can be taken from an atom, leaving a doubly-charged ion. The element helium, with a normal complement of 2 electrons, provides an important example, because the nucleus in this case, which again is also the ion, is

nothing but the alpha particle ejected from many radioactive substances. In what follows we shall often write $_2He^4$ for an alpha particle.

A very common method of obtaining a supply of ions consists in applying a potential difference to the electrodes of a tube containing a gas or a vapour at low pressure. If the resulting electric field is high enough, ions are formed and a current passes through the tube. Obviously with such a tube positive ions will move away from the positive terminal and towards the negative, and, moreover, *the greater the voltage applied to the tube, the greater the velocity acquired by an ion.* Positive ions, therefore, may strike the negative terminal with such high speeds that, if there is a hole in this terminal, some of them will pass through the hole and traverse the region beyond the terminal. If in this region the moving ions pass through an electric field maintained between

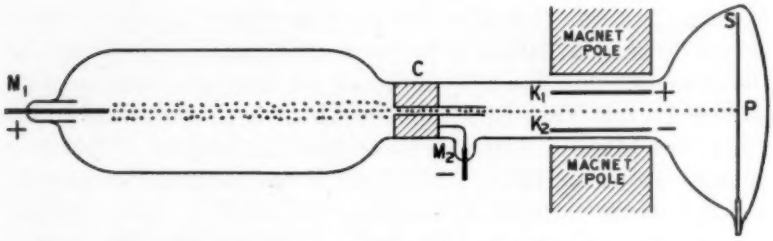

FIG. 1. The dots represent atom-ions which are deflected out of their paths either by an electric field maintained between the plates K_1 and K_2 or by a magnetic field.

the plates K_1 and K_2, Fig. 1, they will be deflected sideways, away from the positive plate, towards the negative. In addition, since moving electrified particles are equivalent to a current, the ions will also be deflected by a magnetic field, in a direction which may be at right angles to the electric deflection if the magnetic field is suitably placed. Moreover, in each case, for ions moving at a given speed in given electric and magnetic fields, *the magnitude of the deflection depends on the mass of the ion, being smaller, the larger its mass,* in accordance with ordinary laws of mechanics. If there is more than one element present in the tube, *it is possible therefore to sort out the ions into groups.* In the pioneer experiments carried out over thirty years ago by the late Sir J. J. Thomson and his assistant F. W. Aston, the arrangement was very similar to that shown in Fig. 1, where the deflecting fields are so placed that each group of ions on

striking a fluorescent screen or a photographic plate gives rise to a curved line. Typical appearances are given in Figs. 2 and 3. Later developments, notably by Aston, Dempster and Bainbridge, so altered and improved the apparatus that the photo-

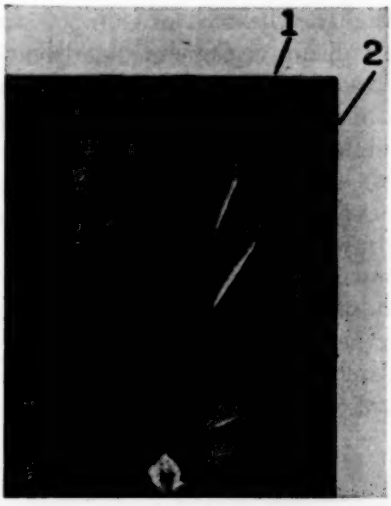

FIG. 2. Courtesy Sir J. J. Thomson, the Royal Society and Longmans Green and Co. The line opposite 1 is due to hydrogen atoms (mass number 1); opposite 2, to hydrogen molecules (mass number 2).

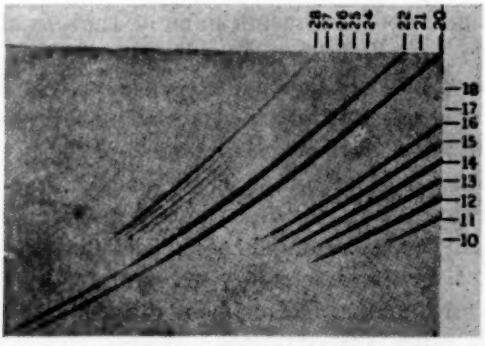

FIG. 3. Courtesy Zeitschrift für Physik. This figure shows clearly the isotopes 20 and 22 of the element neon.

graph showed a successive of short sharp lines, one for each kind of ion, somewhat as illustrated in Fig. 4. For obvious reasons, this is called a *mass spectrum* and the instrument a *mass spectrograph*.

Quantitative analysis of data obtained from mass spectra has led to three extremely important results, two of which are of special interest in the work I am discussing this morning. (1) There are few stable elements which have not two or more *isotopes*, that is, atoms with the same atomic number but different atomic weights. The idea of isotopes was not new, for their existence in radioactive elements had been known for some years before the beginnings of mass spectrography, but it was a new and important fact to find out that a stable element, like chlorine, for example, consists of a mixture of about three parts of atoms of atomic weight 35 and one part of atomic weight 37. Literally hundreds of isotopes are now known, but at this stage of my lecture I draw your attention to only one other element. In 1932 it was shown that hydrogen has a heavy variety of mass number 2, one so important that it was given the special name *deuterium*. So we have both ${}_1H^1$ and ${}_1H^2$, and, as a matter of fact, even the existence of ${}_1H^3$ in very minute quantity has been discovered. (2) and (3). Accurate measurements of mass spectra

FIG. 4. Courtesy K. T. Bainbridge and the *Physical Review*. A characteristic mass spectrum. The lines shown, with the exception of 127, are all due to isotopes of tin.

gave the second important result, namely, that *the atomic weight of each isotope is nearly, although not quite, a whole number*, often called the *mass number*. This point is clearly shown in Table I, which also emphasizes the third result of importance, that *photographs of mass spectra provide a means of measuring atomic weights to a high order of accuracy*.

Before making use of a few of these numbers, it is necessary to speak briefly about atom-smashing and modern transmutation of matter. My first reference takes us back to 1919 when Lord Rutherford bombarded nitrogen with alpha particles from a radioactive source and obtained hydrogen. If we describe the experiment by means of an equation, we write nitrogen + alpha particle = hydrogen + X, or in symbols,

$$ {}_7N^{14} + {}_2He^4 = {}_1H^1 + X, $$

where X is as yet an unknown product. *Note that this equation differs from the equation describing an ordinary chemical reaction*

in one important respect. In such reactions the same atoms appear on both sides of the equation, being merely rearranged, whereas the equation describing the Rutherford experiment represents the death of two atoms and the birth of two others. This can be brought about only when the nuclei of two atoms come together close enough to interact with each other so that a completely new nucleus is formed, one which may or may not break up into two other nuclei. Since all nuclei are positively charged, there is a strong force of repulsion when two come very close together, hence, if we wish to bring about a nuclear reaction, such bombarding bullets as protons and alpha particles must move at high speeds.

TABLE I. ATOMIC WEIGHTS OF A FEW STABLE ISOTOPES

Element	Symbol	Atomic Number	Atomic Weight
hydrogen	$_1H^1$	1	1.00812
hydrogen	$_1H^2$	1	2.01472
helium	$_2He^4$	2	4.00389
lithium	$_3Li^6$	3	6.01690
lithium	$_3Li^7$	3	7.01804
beryllium	$_4Be^8$	4	8.00777
beryllium	$_4Be^9$	4	9.01497
boron	$_5B^{10}$	5	10.01605
boron	$_5B^{11}$	5	11.01286
carbon	$_6C^{12}$	6	12.00398
carbon	$_6C^{13}$	6	13.00766
nitrogen	$_7N^{14}$	7	14.00750
nitrogen	$_7N^{15}$	7	15.00489
oxygen	$_8O^{16}$	8	16.00000
oxygen	$_8O^{17}$	8	17.00450
oxygen	$_8O^{18}$	8	18.0047

In passing let us identify the element X in the Rutherford experiment. If we use the nearly correct whole numbers as atomic weights and assume no loss of mass in the transaction, it follows at once that the atomic weight of X must be 17, since $14+4=1+17$. Again, if we make the further reasonable assumption that when two nuclei coalesce there is no loss of electrical charge, the atomic number of X must be 8, since $7+2=1+8$. Now, there is only one element which has the atomic number 8, and that is oxygen; hence, if the above reasoning is correct, X must be oxygen. Years after Rutherford performed this classic experiment, it was shown that oxygen has an isotope of mass number 17. We may, therefore, sum up the results of this experiment by writing

$$_7N^{14}+{}_2He^4={}_1H^1+{}_8O^{17}$$

It will be noted that Rutherford used Nature's bullets, the

alpha rays from a radioactive source. Nowadays, most bombarding particles are speeded up artificially either by the direct application of extremely high voltages, or by the use of the cyclotron. Particles in common use are listed in Table II. The list

TABLE II

Particle	Symbol	Mass	Charge
proton	${}_1H^1$	1.0081	1+unit
deuteron	${}_1H^2$	2.0147	1+unit
alpha	${}_2He^4$	4.0039	2+units
neutron	${}_0n^1$	1.0089	none
photon	$h\nu$	$\frac{h\nu}{c^2}$	none

includes, in addition to the nuclei of the two hydrogen isotopes and of helium, the *neutron* and the *photon*. As indicated in the table, the neutron is a particle with mass almost, although not quite, equal to that of a proton, but without charge. Its existence was revealed as a result of experiments in which the element beryllium was bombarded by alpha particles, a discovery which, for two reasons, was one of the most outstanding in nuclear physics. First, because, being uncharged, a neutron can penetrate the repulsive barrier around a nucleus very much easier than a positively charged particle, and in consequence, can bring about nuclear transformations with comparative ease. The second reason is the more important for our lecture this morning. The neutron provided a badly needed brick for the building of nuclei.

Let me give two simple examples to illustrate this point. The deuteron with atomic number 1 and atomic weight 2 almost certainly must contain 1 proton and 1 neutron,[1] or in symbols, we may write ${}_1H^2 = {}_1H^1 + {}_0n^1$. Actual experiments, in which nuclei of heavy hydrogen were disintegrated by gamma rays from radium have confirmed the truth of this.

Again, the alpha particle, with its atomic number 2 and mass number 4, evidently is built up of 2 protons, which provide the 2 positive charges, and 2 neutrons, and we may write

$$\text{alpha particle} = 2 \text{ protons} + 2 \text{ neutrons}.$$

Now let us do a little simple arithmetic, making use of the atomic weights given in Table I. Our calculations are summarized in Table III.

[1] Before the discovery of the neutron, the composition of nuclei was explained in terms of protons and electrons, an hypothesis which involved certain difficulties.

TABLE III

mass of proton*	=1.00812	mass of 2 protons	=2.01624
mass of neutron	=1.00893	mass of 2 neutrons	=2.01786
sum	=2.01705	sum	=4.03410
mass of deuteron*	=2.01472	mass of alpha	=4.00389
discrepancy	=0.00233	discrepancy	0.03021

* The masses of the proton and deuteron are less than the numbers given by 0.00055, the mass of an electron. Since in the relation ${}_1H^2 = {}_1H^1 + {}_0n^1$, the proton and deuteron are on opposite sides of the equation, the accuracy of the arithmetic is not affected by using the masses of the atoms rather than those of the nuclei. This is usually done in testing nuclear interactions.

Note that although the agreement in the masses is sufficiently close to justify the assignment of building bricks in this way, there is in each case a discrepancy which is much greater than the experimental error in measurements made on mass spectra. What, then, is the explanation of this apparent loss in mass when a neutron and a proton come together to form a deuteron, or two protons and two neutrons to form an alpha particle?

Before attempting to answer that question, I should like to give two examples of nuclear reactions in which similar discrepancies are found. The first is represented by the nuclear equation

$$ {}_3Li^7 + {}_1H^1 = {}_2He^4 + {}_2He^4, \qquad (2) $$

which states that when the lithium isotope with mass number 7 is bombarded by protons two alpha particles are formed. Now let us add up the masses on each side of this equation, and do the little arithmetic summarized in the upper half of Table IV.

TABLE IV

mass of Li^7	= 7.01804	mass of He^4	= 4.00389
mass of H^1	= 1.00812	mass of He^4	= 4.00389
sum	= 8.02616	sum	= 8.00778

Discrepancy = 0.0184

mass of B^{11}	=11.01286	mass of C^{12}	=12.00398
mass of H^1	= 1.00812		
sum	=12.02098		

Discrepancy = 0.0170

Our work shows that the total mass on one side of the equation differs from that on the other by 0.0184 units. *What about the law of conservation of mass?*

My second example of a nuclear interaction concerns the

bombardment of boron by protons with the production of carbon, or the reaction

$$_5B^{11}+{}_1H^1={}_6C^{12}. \qquad (3)$$

The arithmetic summarized in the lower part of Table IV shows that here again there is an apparent loss of mass of 0.017 units.

To account for these losses and to make our books balance, it is necessary to consider not only the masses involved in such reactions as equation (2) and (3), but also the whole question of energy. When lithium is bombarded by protons, the resulting alpha particles shoot apart from each other with high velocities, and the kinetic energy involved must not be overlooked. Now no tests or explanations can be made until we are able to measure accurately the energy of each alpha particle.

One important method of evaluating the energy of such a particle consists in measuring what is called its *range*. By range we mean the total distance the particle travels, in a medium like air, for example, before it loses its ability to ionize. You are perhaps familiar with the fact that when a high-speed charged particle like a proton or an electron or an alpha ray traverses a gas, its energy is gradually expended in knocking electrons out of some of the atoms with which it collides, thus leaving behind it a trail of ions to mark its path. This type of collision must not be confused with the nuclear reactions we have been discussing. Before a nuclear interaction can take place, there must be a head-on collision between a bombarding particle and a nucleus, and such a collision is a rare event. A nucleus, it must be remembered, occupies about as much space in an atom as a fly in a cathedral, and in many experiments, the chance of a direct hit by a bombarding particle is only one in millions.

Although it is not possible to see an ion, there is a very beautiful method of visualizing the trails of ions left behind by alpha and other particles as they travel along losing their energies, a method which is not only interesting in itself, but also valuable because it can be used to measure energies. Years ago it was shown by C. T. R. Wilson in Cambridge that when a vapour is condensing, ions act as nuclei for the formation of water drops in the same way as dust particles. Just as when dust is present, a drop forms about a dust particle, so, in dust-free air ions act as centres around which a drop or droplet forms. *For each invisible ion, a visible drop appears*, and by photographing a gas traversed by charged particles immediately after condensation has taken

place, a picture showing the paths of the ions is obtained.

A good example of this is shown in Fig. 5, where each of the straight white lines marks the path of an alpha particle ejected from a radioactive source. In this photograph a forked branch will be observed at the end of one of the tracks. This very vividly depicts the Rutherford experiment we have been discussing, because the long thin arm at the left of the fork repre-

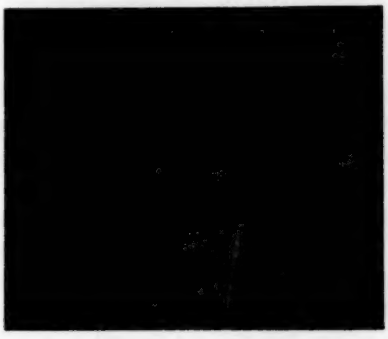

FIG. 5. Courtesy P. M. S. Blackett and the Royal Society. Each line (except the two arms of the fork) represents the path of an alpha particle emitted by a radioactive source.

FIG. 6. Courtesy P. I. Dee, E. T. S. Walton and the Royal Society. The two long lines represent the paths of the alpha particles ejected in opposite directions when a bombarding atom of heavy hydrogen strikes the nucleus of a lithium atom.

sents the path of the proton resulting from the collision of an alpha particle with a nitrogen nucleus, and the short thicker right arm of the fork gives the path of the O^{17} atom.

Fig. 6 illustrates the ejection of two alpha particles in opposite directions when lithum isotope 6 is bombarded by a deuteron. I hope this photograph makes it clear how, by this method, it is

possible to measure the range of the alpha particles in nuclear reactions.

A second method of revealing tracks of particles makes use of the fact that when such particles traverse the fine grain emulsion of a photographic plate, tracks are revealed when the plate is developed. Interesting as this method is, time permits me to do no more than to call your attention to it in passing.

By either of these methods we can measure the range of a particle and then calculate its initial kinetic energy making use of well-known relations connecting range with velocity. So much work of this kind has been done that tables have been compiled giving the ranges of different kinds of particles in a medium such as air and the corresponding velocities. From such tables, for example, we find that an alpha particle with a range of 7 cm in air has an initial velocity of 1.9×10^9 cm per sec. (or about 12,500 miles per sec.); with range 3.9 cm, a velocity 1.6×10^9 cm per sec. and so on.

The energy of a particle may be expressed in ordinary units such as ergs or microergs, but in nuclear physics the unit frequently used is the *electron-volt*. As its name implies, this is the energy acquired by a particle with a charge equal to that on an electron, and hence also on a proton, after it has fallen through a potential difference of 1 volt. Thus, a proton accelerated by a potential difference of 500,000 volts acquires 500,000 electron-volts or 1/2 mev, where mev is the symbol we shall use for a million electron-volts. An alpha particle falling through the same potential difference would acquire 1 mev, because it has a charge of 2 units. For those who like to play with units, a good exercise is to prove that

$$1 \text{ mev} = 1.6\times10^{-6} \text{ erg} = 1.6 \text{ microerg.}$$

Returning now to the experiment in which the two alpha particles were released as a result of the bombardment of Li^7 nucleus by a proton (equation 2), we can now state that energy measurements showed that, when the bombarding photon had 0.3 *mev* of kinetic energy, each of the alpha particles was shot off with 8.7 *mev*. Hence, if we include energy values in our equation, we now write

$$_3Li^7 + {}_1H^1 + 0.3 \text{ mev} = {}_2He^4 + {}_2He^4 + 17.4 \text{ mev.}$$

We are now at last in a position to explain the apparent loss of mass in this and other transactions. To understand the ex-

planation it is necessary to throw overboard completely the idea that inert matter is the only entity which possesses mass, or that the mass of a given particle necessarily remains constant. Even before the nineteenth century was over, Sir J. J. Thomson had shown theoretically that the mass of an *electrified* body should vary with its speed, a deduction which was verified experimentally by experiments on electrons. These experiments showed that the faster an electron moves, the harder it is to push it out of its path by a deflecting field and therefore the greater its mass. *The same electrified body can have different masses under different conditions.*

It is to Einstein, however, to whom we must go to find the real solution of our problem. One of the consequences of the theory of relativity is a law which states that *an increase in the energy of a body represents an increase in its mass and that every form of energy has an equivalent mass. Inert matter has mass, but so has energy.* If you are running you possess energy of motion and your mass is just a little bit more than when you are at rest. It sounds fanciful, and the effect is so small that you could not detect the increase in mass due to the energy of motion of a 200-ton locomotive moving at 60 miles an hour, but it is none the less real. The energy which must be added to 30,000 tons of water to turn it into steam increases the mass of the water by 1 gram.

In symbols, the law of equivalence between mass and energy is given by the simple relation

$$E = mc^2,$$

where c is the velocity of light, m the mass and E the energy. A few corresponding values of E and m are given in Table V.

TABLE V. ENERGY-MASS EQUIVALENTS

m	E
0.00107 atomic weight units	1 mev
1 atomic weight unit	933 mev
1 gram	2.5×10^7 kilowatt-hrs.
2 electrons (rest masses)	1 mev

It follows from this law that in any transaction where both matter and energy are involved, we cannot expect masses to balance or to be conserved unless the mass equivalent of the energies involved is taken into consideration. Let us now see how nearly the two sides of equation (2) balance when we include the mass equivalent of the energy values. From the balance sheet in

Table VI it will be seen that within the limits of experimental error, there is exact agreement.

TABLE VI. CONSERVATION OF MASS IN THE INTERACTION
$_3Li^7 + {}_1H^1 = {}_2He^4 + {}_2He^4$

Before		
Mass of lithium atom		= 7.0180
Mass of bombarding hydrogen atom		= 1.0081
Mass equivalent of 0.3 mev	$= \frac{0.3}{933} =$	.0003
Total		8.0264
After		
Mass of 2 helium atoms		= 8.0078
Mass equivalent of 8.7 mev	$= \frac{8.7}{933} =$	.0093
Mass equivalent of 8.7 mev	=	.0093
Total		8.0264

The law of conservation of mass holds, if we accept Einstein's equivalence of mass and energy.

Let us next apply the same test to the interaction

$$_5B^{11} + {}_1H^1 = {}_6C^{12},$$

in which we have already noted an apparent lose of 0.0170 units of mass. Using the data given in Table V, we find that this corresponds to an energy equivalent of 0.0170×933 or about 16 mev. The discrepancy is then explained if, when $_6C^{12}$ is formed, there is a release of energy of this amount. Experiment shows that when this reaction takes place, there is an emission of gamma radiation whose units of energy have a maximum value of 16.6 mev.

It should here be stated that, when dealing with electromagnetic waves whether in the form of visible light, ultraviolet, X-rays or gamma rays radiant energy can exist only in units called *quanta*. Each quantum has $h\nu$ ergs of energy, where h is Planck's universal constant, of magnitude 6.56×10^{-27} erg $\times$ sec. and ν is the frequency of the radiation involved. The name *photon* which appears in Table II is often applied to a quantum of radiant energy as it is being propagated. In the above reaction, $_5B^{11} + {}_1H^1 = {}_6C^{12}$, a single photon having 16.6 mev of energy, with a mass equivalent of 0.017 units is radiated for each interaction between a proton and the nucleus of an atom of boron.

Your attention has been drawn to other mass defects, namely,

an apparent loss of 0.00233 units when a proton and a neutron unite to form the nucleus of an atom of heavy hydrogen, and a loss of 0.0302 units when an alpha particle is formed out of two protons and two neutrons. We can now see just what these apparent losses mean. Since 0.00233 mass units correspond to 0.00233×933 or about 2 mev, *the apparent loss of mass is accounted for by the release of this amount of energy every time a proton and a neutron come close enough together to form a deuteron. Conversely, if we wish to disintegrate a deuteron, the proton and the neutron cannot be torn apart unless at least 2 mev of energy is communicated to them.* It is significant that by bombarding heavy hydrogen with gamma rays whose photons have 2.6 *mev* of energy, Chadwick and Goldhaber disintegrated the nuclei in accordance with

$$_1H^2 + \text{gamma} = {}_1H^1 + {}_0n^1.$$

The same line of reasoning shows us that if we wish to break up an alpha particle into its constituents of protons and neutrons, energy equal to 0.030×933 or nearly 30 mev is necessary. As yet this has not been accomplished.

Before concluding this lecture with a brief discussion of one or two applications, or possible applications, of the equivalence of mass and energy, I should like to sum up the main conclusion we have reached regarding our three conservation laws. *The law of conservation of matter must be discarded, because inert matter may disappear, even if on only a small scale. The laws of conservation of mass and of energy remain, but in reality boil down to a single law. If energy is conserved, so must mass be, or if mass is conserved, so must energy. In any transaction involving interactions of any kind between substances, the sum total of the mass associated with inert matter and the mass equivalent of energies involved is the same before and after the interaction.*

I should like now to discuss very briefly a very important question on which a great deal of light has been thrown by results of nuclear physics and the application of Einstein's Law. I refer to the problem of accounting for the enormous rate at which the sun emits radiation. *Every second the sun pours into space about 4×10^{23} ergs of radiant energy, or 100 million million million kilowatt-hours, and this has been going on for millions of years.* Using the mass equivalent of this amount of energy, we can express the matter otherwise by stating that *each minute the sun emits 250 million tons of radiant energy. The problem then*

is to find a source which will account for this high rate of production of energy and its continuance over astronomical periods of time. The problem is, of course, not new, and more than one solution has been given. To-day I have neither the time nor the desire to discuss the various theories which have been put forth, and I propose to mention only the latest, and, in the opinion of the experts, by far the most satisfactory theory.

The theory is summed up in the list of relations given in Table VII, a list which is known as the Carbon Cycle.

TABLE VII. THE CARBON CYCLE

$$_6C^{12} + {}_1H^1 = {}_7N^{13} + \text{gamma} \quad (A)$$
$$_7N^{13} = {}_6C^{13} + \text{positron} \quad (B)$$
$$_6C^{13} + {}_1H^1 = {}_7N^{14} + \text{gamma} \quad (C)$$
$$_8N^{14} + {}_1H^1 = {}_8O^{15} + \text{gamma} \quad (D)$$
$$_8O^{15} = {}_7N^{15} + \text{positron} \quad (E)$$
$$_7N^{15} + {}_1H^1 = {}_6C^{12} + {}_2He^4 \quad (F)$$

Even a casual glance at these relations shows several things. (1) *At the completion of the cycle, no carbon atoms whatever have been used up.* (2) *Four protons have disappeared or been consumed, to give rise to the birth of the nucleus of a helium atom.* (3) In addition some gamma radiation has been liberated, and two positrons have been born.

A passing reference has already been made to the positron, the positively charged counterpart of the electron whose existence was discovered in 1932. These particles need not concern us in the problem we are discussing, and we can dismiss them after pointing out that they are known to unite with electrons to give birth to gamma radiation.

From the standpoint of energy, *the important fact is the creation of an alpha particle at the expense of four protons.* To this must be added the two electrons necessary to turn two of the protons into neutrons. Now earlier in the lecture it was emphasized that when an alpha particle is formed from two protons and two neutrons, there is an apparent loss of mass equivalent to a liberation of nearly 30 mev of energy. With only a slight correction this applies to the results of the carbon cycle, and the question at once arises, Does this represent a satisfactory source of energy to account for the observed solar radiation? The answer is entirely in the affirmative. *If we estimate the available supply of protons per gram in the sun, and it is significant that hydrogen is by far the most abundant element in stars, we find that the carbon cycle will provide the necessary energy for*

30 billion years. Jeans puts the result in a slightly different way. "A sun in which only one-fifth of one per cent was hydrogen could provide the present sun's radiation for 2,000 million years—and it is fairly certain that the sun contains more hydrogen than this."

One final word. I am sure you would consider this lecture far from complete if I made no reference to the possibility of using atomic transformations as a practical means of obtaining energy. *The ordinary combustion of 1 gram of coal supplies us with about 1/100 kilowatt-hour. If 1 gram of coal or of any other substance could be annihilated and the released energy utilized, we should have available about 25 million kilowatt-hours. The possibilities of the annihilation of matter are therefore staggering, even frightening.* Is there any chance of our ever putting to practical use such a possible source of energy?

At present there is no evidence that we can bring about annihilation of matter on even a small scale. But we have seen that we can control nuclear transformations in which a bombarding particle, possessing a small amount of energy, causes a nuclear interaction which releases a quantity of energy many times greater. Recall, for example, the release of over 17 mev of energy when lithium is bombarded by protons with only 0.3 mev. This looks like a very profitable business, but the profit is more apparent than real, because for every proton which interacted with the lithium nucleus a few million had to be fired without making a hit at all. The energy expended in firing the large number of protons which did not lead to any interactions is many times greater than the gain in energy from one single successful hit. We certainly cannot count on nuclear reactions of this kind to provide us with a substitute for water-power or fuel.

There is another type of atomic reaction, however, which has greater possibilities. This type was discovered at the beginning of 1939 by Hahn and Strassman after a period of some years in which they and other workers had been examining the effect of exposing the heavy radioactive element uranium (atomic number 92) to the action of neutrons. These experimenters finally showed that, after capture of a slow-moving neutron uranium atoms, notably the isotope 235, break into two atoms of elements near the middle of the periodic table. This process, called *fission* of the heavy atom, is about the nearest approach to real atom-smashing we have.

From the energy standpoint, fission is of great importance because the combined atomic masses of any two elements, near the middle of the periodic table, into which uranium may split, are so much smaller than the atomic mass of uranium that a large amount of energy is released in the process. For example, if the elements xenon and strontium are the fission products, over 200 *mev* is released in a single fission. It is not, however, this large release of energy from a single fission which makes this method of such great significance, but rather the added factor that such fission processes are also accompanied by the liberation of neutrons. Thus *a process started by the capture of neutrons, liberates neutrons. Once started,* then, *why should the process not continue, with the evolution of ever-increasing amounts of energy, until the uranium is all used up? And, if started, could the process be stopped?* These are questions, I leave with you. They may be answered sooner than we think.

I close this lecture with an article of faith. To me the law of conservation of energy is a foundation stone of the universe in more ways than one. In the last analysis, we do not get something for nothing either in science or in life. Nature provides free of charge vast supplies of water-power, but man must harness this by the sweat of his brow. Man will not harness atomic sources of energy without expending an equivalent amount of effort. Value given for value received is a basic principle in science as in life.

AND THE PRIZE IS YOUTH

A powerful tug-of-war is going on between employers on one hand and the schools and educational authorities on the other. The prize is—youth.

Employers point to the great contribution young workers made this summer to industry and agriculture. With the coming of fall, these young workers are still in demand—but they are also wanted by the schools. Some employers claim, however, that without the 'teen age workers food and arms production may drop and that essential civilian services may be crippled.

Washington manpower and education officials are pulling with the schools, but so far the issue is undecided. This picture drawn by the Educational Policies Commission is still true:

By the hundreds of thousands, boys and girls who in other times would have completed high schools, are now leaving school before graduation to go to work. In some communities, the exodus from high school has already reached proportions which are alarming to all concerned for the success of the war effort and for the long-time welfare of youth. In practically all communities, withdrawals have reached the point where they require immediate attention and action. And almost everywhere, the rates of withdrawal are steadily mounting.

VECTORS AND THEIR USES

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In view of the growing importance of vectors in navigation, mechanics, meteorology, aeronautics and applied mathematics in general, it seems that high school courses in mathematics might well provide an introduction to vector algebra and some of its simpler applications in geometry.

1. *Vector Addition. A vector is a segment of a straight line regarded as having a definite length and direction.* The notation $\overrightarrow{AB}$ denotes the vector directed from A to B. Two vectors are said to be *equal* when they have the same length and direction. We shall often use a single bold-face letter to denote any one of a number of equal vectors. Thus in the parallelogram $ABCD$ (Fig. 1)

$$\overrightarrow{AB}=\overrightarrow{DC}=\mathbf{u}, \qquad \overrightarrow{AD}=\overrightarrow{BC}=\mathbf{v}.$$

From the definition of equality we see that a vector $\mathbf{u}$ is not altered by shifting it parallel to itself. This property is expressed by saying that the vector $\mathbf{u}$ is *free*.

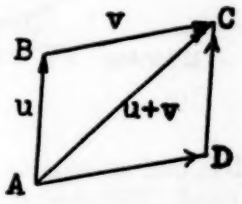

FIG. 1

The sum of two vectors $\mathbf{u}$, $\mathbf{v}$ is defined as follows:

Draw $\mathbf{v}$ *from the end of* $\mathbf{u}$; *then the vector directed from the beginning of* $\mathbf{u}$ *to the end of* $\mathbf{v}$ *is the sum of* $\mathbf{u}$ *and* $\mathbf{v}$ *and is written* $\mathbf{u}+\mathbf{v}$. The definition of vector addition is expressed by the equation

$$\overrightarrow{AB}+\overrightarrow{BC}=\overrightarrow{AC} \tag{1}$$

and may be called the *triangle law*.

Vector addition is *commutative:*

$$\mathbf{u}+\mathbf{v}=\mathbf{v}+\mathbf{u}. \tag{2}$$

For in the parallelogram $ABCD$ of Fig. 1,

$$u+v=\overrightarrow{AB}+\overrightarrow{BC}=\overrightarrow{AC}, \qquad v+u=\overrightarrow{AD}+\overrightarrow{DC}=\overrightarrow{AC}.$$

Thus $u+v$ is the diagonal of a parallelogram having u and v as adjacent sides. For this reason the rule for vector addition is often called the *parallelogram law*

Vector addition is also *associative:*

$$(u+v)+w=u+(v+w). \tag{3}$$

For in Fig. 2,

$$(u+v)+w=(\overrightarrow{AB}+\overrightarrow{BC})+\overrightarrow{CD}=\overrightarrow{AC}+\overrightarrow{CD}=\overrightarrow{AD},$$

$$u+(v+w)=\overrightarrow{AB}+(\overrightarrow{BC}+\overrightarrow{CD})=\overrightarrow{AB}+\overrightarrow{BD}=\overrightarrow{AD}.$$

Since the grouping of the vectors is immaterial, the above sum is simply written $u+v+w$.

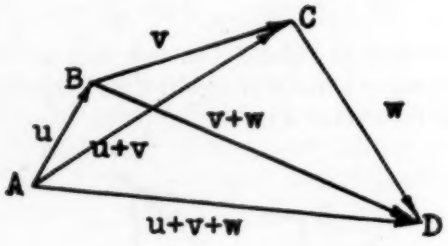

FIG. 2

From the commutative and associative laws we may deduce the following general result: *The sum of any number of vectors is independent of the order in which they are added and of their grouping to form partial sums.* To form the sum of any number of vectors, form a broken line whose directed segments are these vectors taken in any order whatever; then the vector directed from the beginning to the end of the broken line will be the required sum. Thus, for any disposition of the points A, B, C, D, E,

$$\overrightarrow{AB}+\overrightarrow{BC}+\overrightarrow{CD}+\overrightarrow{DE}=\overrightarrow{AE}. \tag{4}$$

If in constructing a vector sum the end-point of the last vector coincides with the origin of the first, we say that their sum is *zero*. Thus we write

$$\overrightarrow{AB}+\overrightarrow{BC}+\overrightarrow{CD}+\overrightarrow{DA}=0; \tag{5}$$

this equation may be regarded as a special case of (4) if we agree to denote such special "vectors" as $\overrightarrow{AA}$, $\overrightarrow{BB}$, etc. by 0. The term *vector* is thus enlarged; besides the *proper* vectors $\overrightarrow{AB}$, which have a definite length and direction, we include the *improper* vector 0, which has a definite length (zero) but no definite direction.

If $\overrightarrow{AB}=u$, it is natural to write $\overrightarrow{BA}=-u$; for then the characteristic equation for negatives $u+(-u)=0$ is satisfied for vectors. Therefore, by definition, ***the negative of a vector is a vector of the same length, but opposite direction.*** Note also that $-(-u)=u$.

Vector subtraction is now defined by the equation

$$u-v=u+(-v); \tag{6}$$

subtracting a vector is the same as adding its negative.

If O is chosen as origin, any point P is located relative to O by giving its position vector $\overrightarrow{OP}$. Any vector $\overrightarrow{AB}$ may be expressed in terms of the position vectors of its end points:

$$\overrightarrow{AB}=\overrightarrow{AO}+\overrightarrow{OB}=\overrightarrow{OB}-\overrightarrow{OA}. \tag{7}$$

2. *Multiplication of Vectors by Numbers.* In analogy with the algebra of real numbers, it is natural to write

$$u+u=2u, \qquad -u+(-u)=-2u.$$

In general, we define:

The product xu or ux of a vector u and a real number x is a vector x times as long as u and having the same direction as u, or the opposite, according as x is positive or negative.

In accordance with this definition we have

$$x(-u)=(-x)u=-xu, \qquad (-x)(-u)=xu,$$

which recall the "rules of sign" in algebra. Moreover, multiplication of a vector by numbers is *commutative* (by definition), *associative* and *distributive:*

$$xu=ux, \qquad (xy)u=x(yu), \qquad (x+y)u=xu+yu. \tag{8}$$

The distributive law also holds in the case

$$x(u+v)=xu+xv; \tag{9}$$

the proof of (9) follows immediately from the proportionality of the corresponding sides of similar triangles. In fact (9) gives an analytic means for dealing with similar triangles and contributes largely to the potency of the vector treatment of geometric problems.

The quotient $\boldsymbol{u}/x$ $(x \neq 0)$ is defined as the product of $\boldsymbol{u}$ by $1/x$.

The developments thus far show that *as far as addition, subtraction, and multiplication by numbers are concerned, vectors may be treated formally in accordance with the rules of ordinary algebra.*

3. *Collinear Points.* When A, B, C are points of a straight line, C is said to divide the segment AB in the ratio y/x when

$$\overrightarrow{AC} = \frac{y}{x}\overrightarrow{CB}. \tag{10}$$

Making use of (7), we can write (10) in the form

$$x(\overrightarrow{OC} - \overrightarrow{OA}) = y(\overrightarrow{OB} - \overrightarrow{OC}); \quad \text{hence}$$

$$\overrightarrow{OC} = \frac{x\,\overrightarrow{OA} + y\,\overrightarrow{OB}}{x+y}. \tag{11}$$

From (10) we see that the ratio of division y/x is positive or negative according as C is interior or exterior to the segment AB.

In the following we shall denote the position vectors of the points A, B, C, $\cdots$ by $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$, $\cdots$. With this notation (11) becomes

$$\boldsymbol{c} = \frac{x\boldsymbol{a} + y\boldsymbol{b}}{x+y}, \tag{12}$$

or, on writing $x+y=-z$,

$$x\boldsymbol{a} + y\boldsymbol{b} + z\boldsymbol{c} = 0, \qquad x+y+z=0. \tag{13}$$

These symmetrical equations constitute a necessary and sufficient condition that the points A, B, C be collinear. When the points are distinct none of the numbers x, y, x is zero, and conversely. In this case we have

$$\boldsymbol{a} = \frac{y\boldsymbol{b} + z\boldsymbol{c}}{y+z}, \qquad \boldsymbol{b} = \frac{z\boldsymbol{c} + x\boldsymbol{a}}{z+x}, \qquad \boldsymbol{c} = \frac{x\boldsymbol{a} + y\boldsymbol{b}}{x+y};$$

hence A divides BC in the ratio z/y, B divides CA in the ratio x/z, C divides AB in the ratio y/x.

4. *Coplanar Points.* When A, B, C, D are points in a plane, either AB is parallel to CD, or AB cuts CD in a point P. In the respective cases we have

$$\boldsymbol{d}-\boldsymbol{c}=k(\boldsymbol{b}-\boldsymbol{a}); \qquad \frac{m\boldsymbol{a}+n\boldsymbol{b}}{m+n}=\frac{r\boldsymbol{c}+s\boldsymbol{d}}{r+s}=\boldsymbol{p}.$$

In both cases a, b, c, d are connected by a linear relation in which the sum of the coefficients is zero, say

$$x\boldsymbol{a}+y\boldsymbol{b}+z\boldsymbol{c}+w\boldsymbol{d}=0, \qquad x+y+z+w=0. \tag{14}$$

Conversely, when equations (14) hold good the points A, B, C, D are coplanar. For example if $x+y=0$ (and hence $z+w=0$) we find that AB and CD are parallel; and if $x+y\neq 0$ (and hence $z+w\neq 0$),

$$\frac{x\boldsymbol{a}+y\boldsymbol{b}}{x+y}=\frac{z\boldsymbol{c}+w\boldsymbol{d}}{z+w}=\boldsymbol{p}$$

where P is necessarily a point common to AB and CD. In both cases A, B, C, D are coplanar.

5. *Applications in Geometry.* With this limited development of vector algebra (without introducing products of vectors) many problems in plane and solid geometry can be readily solved. In the following examples the reader should draw the figure and letter it in accordance with the text.

Example 1. The medians of a triangle meet in a point which divides them all in the ratio of 2/1.

Let P, Q, R be the mid-points of the sides of a triangle opposite the vertices A, B, C. Then, by hypothesis,

$$2\boldsymbol{p}=\boldsymbol{b}+\boldsymbol{c}, \qquad 2\boldsymbol{q}=\boldsymbol{c}+\boldsymbol{a}, \qquad 2\boldsymbol{r}=\boldsymbol{a}+\boldsymbol{b}.$$

In order to find the point G in which the medians AP, BQ meet, eliminate C from the first two equations; thus

$$2\boldsymbol{p}-2\boldsymbol{q}=\boldsymbol{b}-\boldsymbol{a} \quad \text{or} \quad \boldsymbol{a}+2\boldsymbol{p}=\boldsymbol{b}+2\boldsymbol{q}.$$

If we divide both members of the equation by 3, they represent points on AP and BQ respectively (§3), that is, the point G. Hence

$$\boldsymbol{g}=\frac{\boldsymbol{a}+2\boldsymbol{p}}{3}=\frac{\boldsymbol{b}+2\boldsymbol{q}}{3}=\frac{\boldsymbol{a}+\boldsymbol{b}+\boldsymbol{c}}{3}=\frac{\boldsymbol{c}+2\boldsymbol{r}}{3},$$

so that G also lies on the median CR and divides each median in the ratio of 2/1.

Example 2. If $ABCD$ is a trapezoid such that $\overrightarrow{AB}=2\overrightarrow{DC}$, and E is the mid-point of BC, in what ratio do the lines AE, BD divide each other?

By hypothesis

$$\mathbf{b}-\mathbf{a}=2(\mathbf{c}-\mathbf{d}), \qquad 2\mathbf{e}=\mathbf{b}+\mathbf{c}.$$

To find the point P in which AE and BD intersect eliminate $\mathbf{c}$ from these equations; thus we find

$$\mathbf{b}-\mathbf{a}=4\mathbf{e}-2\mathbf{b}-2\mathbf{d} \quad \text{or} \quad 3\mathbf{b}+2\mathbf{d}=\mathbf{a}+4\mathbf{e}.$$

Hence (§3)

$$\mathbf{p}=\frac{3\mathbf{b}+2\mathbf{d}}{5}=\frac{\mathbf{a}+4\mathbf{e}}{5};$$

thus P divides BD in the ratio 2/3, AE in the ratio 4/1.

Find the point Q where CP cuts AB. To this end we seek a linear relation between $\mathbf{c}$, $\mathbf{p}$, $\mathbf{a}$, $\mathbf{b}$. This may be obtained by eliminating $\mathbf{d}$ from

$$\mathbf{b}-\mathbf{a}=2\mathbf{c}-2\mathbf{d} \quad \text{and} \quad 5\mathbf{p}=3\mathbf{b}+2\mathbf{d},$$

or eliminating $\mathbf{e}$ from

$$2\mathbf{e}=\mathbf{b}+\mathbf{c} \quad \text{and} \quad 5\mathbf{p}=\mathbf{a}+4\mathbf{e}.$$

Either process gives

$$\mathbf{q}=\frac{\mathbf{a}+2\mathbf{b}}{3}=\frac{5\mathbf{p}-2\mathbf{c}}{3};$$

thus Q divides AB in the ratio 2/1 and CP (externally) in the ratio $-5/2$. Or since $5\mathbf{p}=2\mathbf{c}+3\mathbf{q}$ we may say that P divides CQ in the ratio 3/2.

We next consider a problem in solid geometry.

Example 3. The lines joining the three pairs of opposite edges in a tetrahedron meet in a point G which divides each segment in half.

Let $ABCD$ denote the vertices of a tetrahedron, P, Q, R the mid-points of BC, CA, AB; X, Y, Z the mid-points of AD, BD, CD. Then, by hypothesis,

$$2\mathbf{p}=\mathbf{b}+\mathbf{c}, \qquad 2\mathbf{q}=\mathbf{c}+\mathbf{a}, \qquad 2\mathbf{r}=\mathbf{a}+\mathbf{b},$$
$$2\mathbf{x}=\mathbf{a}+\mathbf{d}, \qquad 2\mathbf{y}=\mathbf{b}+\mathbf{d}, \qquad 2\mathbf{z}=\mathbf{c}+\mathbf{d}.$$

Evidently (§3)

$$\boldsymbol{g}=\frac{\boldsymbol{p}+\boldsymbol{x}}{2}=\frac{\boldsymbol{q}+\boldsymbol{y}}{2}=\frac{\boldsymbol{r}+\boldsymbol{z}}{2}=\frac{\boldsymbol{a}+\boldsymbol{b}+\boldsymbol{c}+\boldsymbol{d}}{4}.$$

If G_1, G_2, G_3, G_4 are the points in which the medians of the faces opposite A, B, C, D intersect, we have (Ex. 1)

$$3\boldsymbol{g}_1=\boldsymbol{b}+\boldsymbol{c}+\boldsymbol{d}, \qquad 3\boldsymbol{g}_2=\boldsymbol{a}+\boldsymbol{c}+\boldsymbol{d}, \quad \text{etc. and hence}$$

$$\boldsymbol{g}=\frac{\boldsymbol{a}+3\boldsymbol{g}_1}{4}=\frac{\boldsymbol{b}+3\boldsymbol{g}_2}{4}=\frac{\boldsymbol{c}+3\boldsymbol{g}_3}{4}=\frac{\boldsymbol{d}+3\boldsymbol{g}_4}{4}.$$

Thus G divides each segment from a vertex to the intersection of the medians in the face opposite in the ratio of $3/1$.

The results above are still valid when the points A, B, C, D are coplanar.

Example 4. Desargues' Theorem. If the triangles ABC, $A_1B_1C_1$ are in perspective from the point E, the points of intersection of their corresponding sides are collinear (Fig. 3).

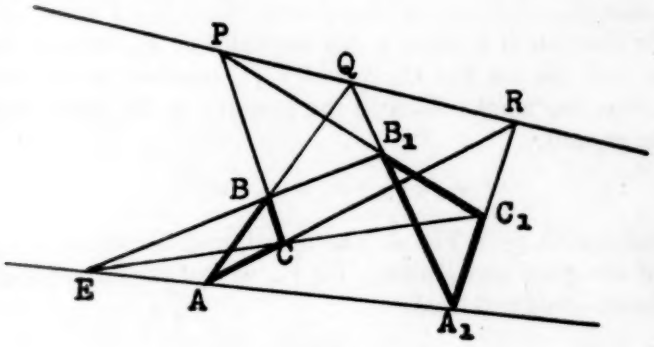

FIG. 3

We merely sketch the proof. By hypothesis (§3)

$$\boldsymbol{e}+x\boldsymbol{a}+x_1\boldsymbol{a}_1=0, \qquad 1+x+x_1=0,$$
$$\boldsymbol{e}+y\boldsymbol{b}+y_1\boldsymbol{b}_1=0, \qquad 1+y+y_1=0,$$
$$\boldsymbol{e}+z\boldsymbol{c}+z_1\boldsymbol{c}_1=0, \qquad 1+z+z_1=0.$$

By eliminating $\boldsymbol{e}$ from the three pairs of these equation we find that the points P, Q, R in which BC and B_1C_1, CA and C_1A_1, AB, A_1B_1 intersect are given by

$$\boldsymbol{p}=\frac{y\boldsymbol{b}-z\boldsymbol{c}}{y-z}, \qquad \boldsymbol{q}=\frac{z\boldsymbol{c}-x\boldsymbol{a}}{z-x}, \qquad \boldsymbol{r}=\frac{x\boldsymbol{a}-y\boldsymbol{b}}{x-y}.$$

Since

$$(y-z)\boldsymbol{p}+(z-x)\boldsymbol{q}+(x-y)\boldsymbol{r}=0$$

we conclude that P, Q, R are collinear (§3).

The proof is also valid when both triangles lie in a plane. Note also the metric character of the proof: when the ratios in which E divides the segments AA_1, BB_1, CC_1 are given, the last equation determines the spacing of P, Q, R.

6. *Composition of Velocities.* The velocity of a particle, relative to a definite frame of reference, is represented by a vector whose length, on a certain scale, gives its numerical speed and whose direction shows the direction of motion. Consider now the motion of a particle c (a body which, for the problem at hand, can be regarded as concentrated at a point) whose velocities relative to the frames a and b are $\boldsymbol{v}_{ca}$ and $\boldsymbol{v}_{cb}$. Then if frame b has the velocity $\boldsymbol{v}_{ba}$ relative to frame a,

$$\boldsymbol{v}_{ca}=\boldsymbol{v}_{cb}+\boldsymbol{v}_{ba}. \tag{15}$$

This vector equation is known as the law of *composition of velocities*.

For example if a plane p has the velocity $\boldsymbol{v}_{pa}$ relative to the air a, and the air has the velocity $\boldsymbol{v}_{ag}$ relative to the ground g ($\boldsymbol{v}_{ag}=\boldsymbol{w}$, the wind velocity), the velocity of the plane relative to the ground,

$$\boldsymbol{v}_{pg}=\boldsymbol{v}_{pa}+\boldsymbol{v}_{ag}=\boldsymbol{v}_{pa}+\boldsymbol{w},$$

is constructed as in Fig. 4. The length and direction of $\boldsymbol{v}_{pa}$ are called *air-speed* and *heading;* for $\boldsymbol{v}_{pg}$ we speak correspondingly of *ground-speed* and *track*.

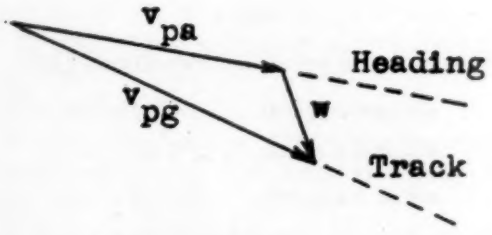

FIG. 4

The *problem of interception* involves a simple application of these ideas. A plane p departs from a point P with the ground velocity $\boldsymbol{v}_{pg}$ at the same instant a plane $\boldsymbol{r}$ departs from a point R.

If the ground-speed of r is known, over what track shall it fly in order to intercept p?

In order that r *intercept plane* p, v_{rp}, *the velocity of* r *relative to* p, *must have the direction* $\overrightarrow{RP}$. Now

$$v_{rg} = v_{rp} + v_{pg}, \qquad v_{rp} = v_{rg} - v_{pg}.$$

Hence (Fig. 5) draw the vector $\overrightarrow{RA} = -v_{pg}$, and from A as center describe a circle of radius equal to the ground speed of r. If this circle cuts the *ray* (half-line) RP in the point B, interception will take place at I when r follows the track RI parallel to $\overrightarrow{AB}$. For in the vector triangle RAB,

$$\overrightarrow{RB} = \overrightarrow{RA} + \overrightarrow{AB} = -v_{pg} + v_{rg} = v_{rp}.$$

Several cases may occur. Interception is impossible if the circle fails to cut the ray RP. If there is just one point of intersection on this ray, as B in Fig. 5, p can only be intercepted on a track parallel to AB. But if the circle cuts the *ray* RP in two points B_1 and B_2, p can be intercepted on tracks parallel to $\overrightarrow{AB_1}$ and AB_2.

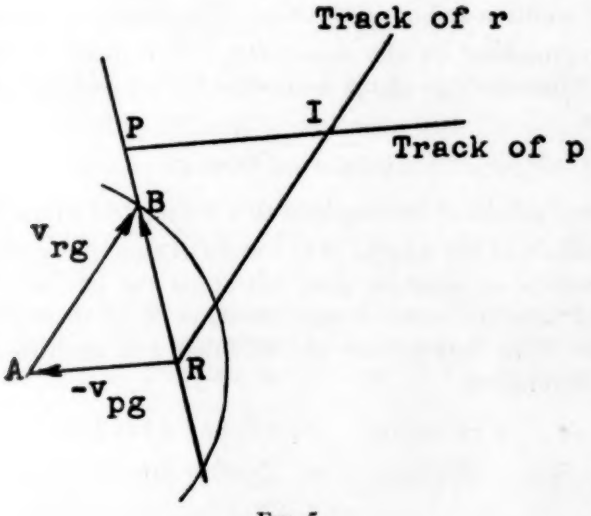

FIG. 5

If speeds are given in miles per hour, the time of interception in hours is given by the quotient of the lengths RP/RB.

7. *Applications in Algebra.* In applying algebra to metric geometry the basic fact is the one-to-one correspondence be-

tween the continuum of real numbers and the totality of points on a directed line. The origin O on the line (chosen at pleasure) corresponds to *zero;* a point U, in the positive direction from O, corresponds to *one;* all the integers

$$\cdots, -2, -1, 0, 1, 2, \cdots$$

are then fixed on the line by their natural order and equal spacing. We next locate the points corresponding to the rational numbers p/q in the usual manner. The totality of rational numbers is *denumerable* (they may be put in one-to-one correspondence with the integers) and *dense* (between any two, however close, there is always another). Finally the points corresponding to irrational numbers are determined as the limits of sequences of rational numbers. Thus all the points on an indefinite straight line give a geometric picture of the real continuum.

The question now arises: When real numbers are added or multiplied what are the corresponding operations on the points which represent the numbers? Thus if the numbers a, b correspond to the points A, B, how can we locate the points corresponding to $a+b$ and ab. To express the geometrical counterpart of addition and multiplication, it is simpler to regard a and b as represented by the *vectors* $\overrightarrow{OA}$, $\overrightarrow{OB}$ instead of the *points* A, B. Then the sum of the numbers $c=a+b$ corresponds to the vector

$$\overrightarrow{OC}=\overrightarrow{OA}+\overrightarrow{OB}.$$

The product $d=ab$ corresponds to a vector $\overrightarrow{OD}$ whose length is the product of the lengths of $\overrightarrow{OA}$ and $\overrightarrow{OB}$ and whose direction is the positive or negative direction along the line according as a and b have the same or opposite signs. With these definitions the five laws that govern the addition and multiplication of positive integers.

$$a+b=b+a, \qquad (a+b)+c=a+(b+c),$$
$$ab=ba, \qquad (ab)c=a(bc),$$
$$a(b+c)=ab+ac.$$

have their validity extended to the continuum of real numbers. In fact the definitions of addition and multiplication were expressly designed to accomplish this end—in accordance with the principle of the *permanence of form.*

It is well known that equations such as

$$x^2+1=0, \qquad x^2+2x+3=0,$$

have no solutions among the real numbers. To remedy this defect we create an extended number system, the system of *complex numbers*, which includes the real numbers as a part, and whose operations shall conform as nearly as possible to the laws given above (permanence of form!). The simplest way to accomplish this is to postulate numbers z which correspond to the vectors $\overrightarrow{OZ}$ of a plane that issue from a fixed origin, one number for each point Z of the plane. In this *complex plane* we draw a directed line OX through O to represent the *axis of reals*. The vectors $\overrightarrow{OZ}$ on the axis of reals correspond to the real numbers; while the vectors $\overrightarrow{OZ}$ not on this axis represent new numbers z, which with the real numbers, constitute an extended number system, the system of *complex numbers*.

We now define the sum and product of the complex numbers corresponding to $\overrightarrow{OA}$ and $\overrightarrow{OB}$. Their *sum* shall correspond to the vector

$$\overrightarrow{OC}=\overrightarrow{OA}+\overrightarrow{OB};$$

their *product* to a vector $\overrightarrow{OD}$ whose length is the product of the lengths of $\overrightarrow{OA}$ and $\overrightarrow{OB}$, and whose angle with the axis of reals, reckoned counterclockwise, is the sum of the angles that $\overrightarrow{OA}$ and $\overrightarrow{OB}$ make with this axis. In brief, complex addition is *vector addition*, while for complex multiplication, *multiply the lengths and add the angles*.

When $\overrightarrow{OA}$ and $\overrightarrow{OB}$ lie along the axis of reals, these definitions conform with those given above for real algebra. Moreover it is easy to see that all five laws for addition and multiplication are preserved:*

$$\overrightarrow{OA}+\overrightarrow{OB}=\overrightarrow{OB}+\overrightarrow{OA}, \qquad (\overrightarrow{OA}+\overrightarrow{OB})+\overrightarrow{OC}=\overrightarrow{OA}+(\overrightarrow{OB}+\overrightarrow{OC}),$$

$$\overrightarrow{OA}\cdot\overrightarrow{OB}=\overrightarrow{OB}\cdot\overrightarrow{OA}, \qquad (\overrightarrow{OA}\cdot\overrightarrow{OB})\cdot\overrightarrow{OC}=\overrightarrow{OA}\cdot(\overrightarrow{OB}\cdot\overrightarrow{OC}),$$

$$\overrightarrow{OA}\cdot(\overrightarrow{OB}+\overrightarrow{OC})=\overrightarrow{OA}\cdot\overrightarrow{OB}+\overrightarrow{OA}\cdot\overrightarrow{OC}.$$

* The products denoted by dots are *not* the "dot-products" of Gibbs' vector algebra.

The first four are obvious; and the fifth (the distributive law) simply says that if the sides of a parallelogram are stretched in a given ratio and revolved through an angle α, the diagonal will also be stretched in this ratio and revolved through α.

Now draw a second directed line OY in the complex plane perpendicular to OX and with its positive direction upward (Fig. 6). If axis OX is revolved 90° counterclockwise about O it will coincide with axis OY, and the point U, corresponding to 1, will go into a point I. Denote the number corresponding to $\overrightarrow{OI}$ by i. Since $\overrightarrow{OI}$ has the length 1 and angle 90°, i^2 corresponds to a vector of length 1 and angle 180°; that is,

$$i^2 = -1.$$

A real number x on OX goes into ix on $\overrightarrow{OY}$; thus all vectors $\overrightarrow{OY}$ represent real multiples of i.

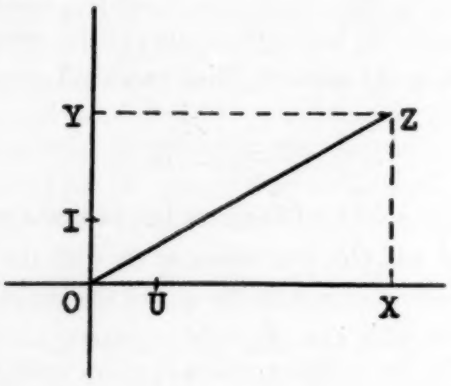

FIG. 6

Any vector $\overrightarrow{OZ}$ in the complex plane may be resolved uniquely into a sum of vectors along OX and OY. Hence (Fig. 6)

$$\overrightarrow{OZ} = \overrightarrow{OX} + \overrightarrow{OY};$$

and if = denotes correspondence between vector and number,

$$\overrightarrow{OX} = x, \qquad \overrightarrow{OY} = yi, \qquad \overrightarrow{OZ} = x + yi,$$

where x and y are real. Thus any vector $\overrightarrow{OZ}$ in the complex plane corresponds to the complex number $x+yi$. Sums and products

of complex numbers obey the rules of ordinary algebra, with the sole proviso that i^2 is to be replaced by -1; for example

$$(a+bi)+(c+di)=a+c+(b+d)i$$
$$(a+bi)(c+di)=ac-bd+(ad+bc)i.$$

By use of the vector concept both real and complex numbers are dealt with in a simple manner, without any mysticism about "imaginary" numbers. Both correspond to vectors in a plane. For "real" numbers x, the vectors lie along a certain line, the "axis of reals" OX; for "pure imaginary" numbers yi, the vectors lie along a perpendicular line, the "axis of imaginaries" OY. The general complex number $z=x+iy$ corresponds to an arbitrary vector $\overrightarrow{OZ}$ in the complex plane. To add complex numbers use vector addition; to multiply them, multiply the lengths and add the angles. It's as simple as that.

LEADING CAUSES OF DRAFT REJECTIONS

The leading causes of draft rejections among 18 and 19 year olds are reported by Col. Leonard G. Rowntree, Kenneth H. McBill and Dr. Thomas I. Edwards, of national headquarters of the Selective Service System, in the *Journal of the American Medical Association.*

For white youths the 10 leading causes of rejection during December, 1942, and January and February, 1943, were, in decreasing order of occurrence: eye defects, mental disease, musculoskeletal defects, heart and blood vessel defects, ear defects, hernia, neurologic defects, educational deficiency, underweight and mental deficiency.

For Negroes during the same period the 10 leading rejection causes were: educational deficiency, syphilis, heart and blood vessel defects, mental disease, musculoskeletal defects, hernia, eye defects, neurologic defects, mental deficiency and tuberculosis.

Of the white youths called up for physical examination, 23.8% were rejected at local boards or induction stations. The rate was almost twice as high for Negroes, 45.5%. The rates are only slightly lower than for older registrants but, the Selective Service officials point out, one should be cautious in drawing conclusions from this. Large numbers of physically fit 18 and 19 year olds entered the armed forces by enlistment, and the Selective Service figures do not cover findings on these youths. An additional number are in schools or colleges and their examinations postponed until after this training period. Still others are deferred because of employment in war industry or agriculture.

Comparison of rejection causes between the 18 and 19 year olds and the older men called up previously cannot be made very readily because standards for eyes, teeth and educational qualifications have been revised and increased attention given to psychiatric examination.

Between November, 1940, and May, 1941, the 10 leading causes of rejection for White and Negroes combined, aged 21 to 36, were: teeth, eyes, heart and blood vessel defects, musculoskeletal defects, mental and nervous defects, hernia, ears, feet and tuberculosis and other lung defects.

CHEMISTS AND THE WORLD AT WAR

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Little is heard or read today by the layman about the position of the chemist in this world at war. The connection between science and the war, as far as the prospective soldier is concerned, is restricted almost entirely to physics and meteorology. Despite this unawareness of the position of chemistry in the world today and the de-emphasis of this science in the schools, nevertheless the tide of battle on the fighting front and the morale on the home front are gravely dependent on chemists. The cultured person should be informed about the chemist in relation to civilian defense, health and nutrition, industry, and manpower—the four areas of the most important war problems from the viewpoint of its execution.

The purpose of civilian defense is the conservation of life and property. The possible causes for such losses in the United States during the war are bombs, fires, and gases. The chemist, to his chagrin, has developed and perfected the explosives in bombs. A century ago, the only war explosive to merit attention was black gunpowder. Today, it is seldom mentioned. Instead, people now read about H. E. (high explosive) and detonators, boosters, and bursters. Nearly all airplane projectiles have these essential parts. The detonator is very sensitive. When discharged, it sets off the booster which in turn explodes the burster. In civilian defense, the delegated soldiers, who alone are authorized to neutralize unexploded bombs, are reasonably secure once the detonator has been removed. The chemist aims to make explosives that are not only sensitive and powerful but also stable. Stability means the property by which the explosive will neither deteriorate nor discharge unexpectedly. How embarrassing it would be to an officer to find, after he has maneuvered his vessel into a strategic position, that his ammunition has deteriorated. Just a few weeks ago, a shipping clerk was killed while nailing a box of explosives. In spite of accidents that do occur, chemists have wrought wonders in their control of explosives. T.N.T., the best known of the high explosives, can be sawed, drilled, pierced by a bullet and even set on fire without exploding.

The chemist's part in fires is to provide materials for causing

them where and when strategy indicates and to prevent them otherwise.

Incendiary bombs were invented by chemists. Some contain phosphorus, some oil and phosphorus, some magnesium and thermite. The chemist aims to devise mixtures that catch fire readily and burn so intensely that the flames cannot be extinguished. The manufacture of tracer bullets, flares, and star shells is closely related to the production of incendiaries. In contrast to his work of initiating fires, the chemist discovers means of extinguishing and preventing them and diminishing the possible damage. He it was who dictated one method of extinguishing the electron bomb and then changed his mind. This trait of adopting the best is characteristic of good scientists, even though they may have to admit that their theory does not explain the empirical application. Prevention of damage is being continually investigated—there are fireproof and fire-resistant clothes, curtains, and lumber, most of which have been devised by chemists.

The problem of war gases, at least the propaganda angle, is becoming serious. The press reports recently that Germany has shipped two carloads of gas into Russia and that the United States now has a gas so destructive that the war could be terminated abruptly if the military command chose to use the material. The evaluation of these reports is uncertain, particularly since the populace at large has been informed in the basic civilian defense courses that the best defense against war gas is to be prepared to use it and to let the enemy know what your potential power is in this respect. In any eventuality, Americans are assured that, due to the work of chemists, our country is as far advanced in offensive and defensive preparations for gas warfare as any nation in the world. Flight from gas attacks, as taught to civilians, is not sufficient defense for soldiers. Combat men must have efficient masks and clothing. The absorbent materials are products of the chemical laboratory.

To aid "first aiders," the chemist discovers effective blood coagulants, antiseptics, stimulants, and germicides. Along with the biochemist he studies the storage and preservation of blood and plasma. After raw blood is centrifuged, the plasma is drawn off the top of the heavier mass. It is frozen, dehydrated, packaged in vacuo. With the dehydrated plasma is a bottle of distilled water which is sealed in nitrogen. It is apparent that the principles and discoveries of the chemist are applied

throughout the procedures used in plasma and blood transfusions.

Another health angle with which the chemist is concerned is the processing of foods. Dehydration is getting much publicity now. The chemist decides the methods of cleansing, blanching, preserving, and packaging. Some of the dehydrated food is packed in airtight containers filled with nitrogen. The chemist is experimenting continually to invent containers that will withstand shock, water, humidity, heat and cold, and exposure to war gases. Because this is a global war, the packaging problem is very serious and challenging.

Dehydration is only one of many methods of processing food. No matter which method is used, there is danger of losing vitamin and mineral content. The chemist determines the natural content and aims to keep it there. If loss during treatment is unavoidable, he contrives, as in the case of enriched flour, to restore the materials. The chemist is concerned also with the retention of the natural colors and their restoration. To prevent decomposition, he works on preservatives. The authorities are employing many chemists and dieticians to plan, a month in advance, menus for meals all over the world. These men are constructing emergency rations also that will provide a balanced diet as well as sufficient energy for our combat men who may be stranded—perhaps trapped in enemy territory, lost in a wilderness, exposed to the disturbing isolation of the high seas. Parachutists particularly must have a compact supply of food. Ration K is made for them. It consists of three separate units, one for each meal. Each contains two different types of biscuits, canned meat or cheese, a confection, a beverage concentrate, chewing gum to allay thirst, and four cigarettes. The meat units, confections, and beverages are different for each of the three meals. The prepared food needs no cooking.

Besides the processing of foods, another health problem for the chemist is the isolation and synthesis of drugs and the discovery of substitutes. The "miracle" or sulfa drugs—thiazole, pyridine, amide—were discovered by chemists. It is the chemist who synthesized atabrine, a substitute for quinine which is so essential in tropical areas to counteract malaria.

The current industrial problems of the chemist are better known than most of the material which has been presented already. The synthetic rubber plants produced some 150,000 tons during 1942. Rubber-chief Dewey has sufficient priorities

to insure the production of about 500,000 tons this year. However, this amount is 100,000 tons short of the peacetime consumption in recent years. Some natural rubber is trickling into the country. "They say" that cargo vessels to far-eastern Russia return with Japanese rubber. The Nazis have recently protested to Japan about this report. Some rubber comes from Ceylon on the return trips from India and China.

Petroleum chemists are doing astounding things these days. They are not only producing better octane gasoline for airplanes; simultaneously, they are making toluene from petroleum crude for the first time in history. Toluene is the basic material for T.N.T. The same wonder workers are now making alcohol from petroleum. This achievement gives an insight into the cause for the rivalry between the agricultural and petroleum interests.

The more familiar metallurgical problems involve aluminum and magnesium. Where two years ago the Aluminum Company of America was producing 180,000,000 pounds of aluminum annually, three billion pounds are now being produced in the United States. Magnesium production has more than quadrupled in twenty months. The magnesium is not used exclusively for incendiary bombs; most of it goes into the manufacture of airplanes because it is lighter than even aluminum. One of the miracle plants is in Texas where both magnesium and chlorine are obtained from sea water. Where magnesium sold for five dollars a pound during World War I, the government now buys it at 28 cents a pound. Other metals of current interest because they were stressed during the salvage campaigns are tin and iron. Chemists are working on cheaper and faster metallurgical processes for both of them.

The development of the plastic industry is fascinating. Some familiar plastics that have gone to war are cellophane and plexiglass. All the plastics have been discovered by chemists. One of the war problems is to get tough transparent ones that will not be etched and rendered opaque by abrasion, especially by the sand encountered in North Africa. The synthetic textile industry is furnishing nylon and glass thread. Nylon is suitable for parachutes. Glass fabric is being used as fire-proofing and insulation material.

Some of the more glamorous problems on life preservation with which chemists are working are flares and fluorescent paints and powders used by men stranded on the high seas. The dyes, when spread on the water, can be detected by airplanes at great

heights. The rubber boats carry carbon dioxide cartridges for inflating them. One of the most critical problems for which there is not yet a satisfactory solution is a method for rendering sea water suitable for drinking. The statement that "we are doing the improbable today and taking a little longer to do the impossible," is being reiterated in regard to the unprecedented achievements of science and industry today. Converting sea water to potable water seems to rate as "impossible," judging from the time it is taking to get a suitable emergency device.

What is the status of the chemist in relation to the manpower problem? All professional chemists registered months ago with the National Research Council. The compiled roster places at the disposal of the government every chemist in the nation. Most of the research work on implements of war is routed through the Office of Scientific Research and Development. Last year this office made research contracts with 94 university laboratories and 110 industrial laboratories. Science and scientists are indeed mobilized. One discovery alone has already saved 100 million dollars in the manufacture of high explosives. To insure other types of research, the War Production Board has organized the Office of Production Research and Development. This group fosters and finances discoveries related to essential industries. Chemists in military uniform belong to the Chemical Warfare Service. They are identified by their symbol of a pair of crossed retorts. The C. W. S. is responsible for all the chemical plants owned by the government—and there are a surprisingly large number of them now. It investigates insecticides, germicides, drugs, explosives—anything that pertains to the execution of war. What is the status of the chemist in regard to Selective Service? Most civilian chemists are engaged in essential war industries. Hence, as a rule, they are deferred by the Draft Boards. To their credit, perhaps, but not to the welfare of the country some have enlisted in the combat forces. The shortage of chemists is being relieved to some extent by the entrance of women in larger numbers into this field of activity. Naturally the American Chemical Society is concerned about the possibility of these slightly trained women displacing the professional chemist. However, if all employers follow the rumored policy of the Standard Oil Company, there need be little fear. Standard Oil aims to get the prettiest women there are. The purpose is to be reasonably certain that all the women employees will marry after the war and thus provide vacancies for men. This solution

seems to have been circulated for the benefit of speech-makers only.

This bird's-eye view of the position of the chemist in a world at war may lead the reader to deduce that the world would be better off without these men who promote war so expertly. However, chemists in general do more for peacetime happiness than for wartime slaughter. They themselves appreciate their paradoxical position in world economy. That their discoveries are adaptable to life or death, to construction or destruction, is no fault of theirs. Like Nobel, who has endowed the greatest peace awards there are and who discovered dynamite, most of them would gladly invest their earnings to secure permanent peace and to promote the arts and sciences that make life worthwhile.

AMERICAN CORK WILL ASSURE FUTURE SUPPLY

Cork for America's future needs is the objective of an ambitious planting project, participated in by federal and state forestry departments, numerous civic organizations and thousands of young people in school science clubs and Scout troops. A hundred thousand seedling cork-oak trees have been set out during the past three seasons, and by the end of the present autumn at least double that number will have been added.

Stimulus for this unusual program has been the embarrassing situation in which many American cork-using industries found themselves when access to the only cork-growing region that really counts at present was dangerously threatened by the war. The native home of the cork is the mountainous regions on both shores of the Western Mediterranean—Portugal and Spain on one side, Spanish and French North Africa on the other. When the Nazis overran France and achieved control of her North African holdings, that naturally took a large part of the cork crop out of our reach. Portugal and Spain remained neutral, but to get ships in and out of their ports involved running the thickest part of the submarine gantlet.

Lack of cork means a lot more than trouble in getting stoppers for bottles. Bottle corks, indeed, are not the most important use for cork by any means. Cork blocks are needed for life belts and fishing net floats; corkboard for insulation in refrigerators and house walls; cork gaskets for many uses; composition cork for crown cap liners; finely ground cork for heavy-duty linoleum, and various forms of cork for a hundred other purposes. Cork is one of those versatile natural materials, like leather, that can do a lot of jobs well, and for which there is no single acceptable substitute.

Without popular education no government which rests on popular action can long endure; the people must be schooled in the knowledge and if possible in the virtues upon which the maintenance and success of free institutions depend.

—WOODROW WILSON

SOURCE MATERIAL FOR SECONDARY SCHOOL GEOGRAPHY

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The world situation is compelling teachers and school administrators to inaugurate courses in political geography in the secondary schools. Dr. John W. Studebaker, United States Commissioner of Education, says: "We are more illiterate geographically than any civilized nation."—because—"Our young people have stopped studying geography in about the seventh or eighth grade." To aid those who have the problem of new courses for the secondary school, the following list of books is submitted, not as class texts, but for geographical ideas and interpretations.

The attention given Haushoferism is to indicate the danger of disregarding the study of "world power politics" and the necessity of teachers being fully informed as to the falseness of much of the German brand of the new geopolitics. Considerable attention must be given the economic influences of raw materials as a basis for the geographical understanding of world relations, hence references to some of the most usable of these sources.

The organization of class material from these sources should provide some real and much needed geographical thinking in the secondary school. The necessary geographical understanding cannot be obtained as a subsidiary product in history or general social studies. There must be some real geography content courses if we are to remedy our past neglect.

America's Strategy in World Politics, by Nicholas J. Spykman, Professor of International Relations, Yale University. Cloth. XV chapters, 495 pages, 6 maps. 24×15 cm. 1942 Harcourt, Brace and Company, New York. $3.75.

A comprehensive survey of the United States in the present geopolitical situation. Not much comfort for dreamers here. Dr. Isaiah Bowman, President of Johns Hopkins University says: "On the ground of merit and public value it should be read in not less than a million American homes." An analysis of the position of our country in terms of geography and power politics is the author's description of his book.

German Strategy of World Conquest, by Derwent Whittlesey, Professor of Geography, Harvard University with the collaboration of Charles C. Colby, Professor of Geography at the University of Chicago and Richard S. Hartshorne, Professor of Geography at the University of Wisconsin. Cloth. XII chapters, 287 pages, 29 maps. 20.5×14 cm. 1942. Farrar and Rinehart Inc., New York. $2.50.

This book unmasks the falseness of Haushoferism and presents a clear analysis of the deceitful use of geographical facts and half truths in the

world power struggle. The Mackinder theory of the Heartland and its future role in the world struggle is correctly evaluated and its halo dimmed.

Generals and Geographers, by Hans W. Weigert, Professor of International Relations at Trinity College. Cloth. X chapters, 271 pages. 21×14.5 cm. 1942 Oxford University Press, New York. $3.00.

Each chapter is an emotional treatment of facts and the leading German personalities. We may not agree with his "The battle of birth rates is shaping the world's history in our time." He shows clearly that the German Geopolitik is a mixture of crude and cruel force with some factual data.

The World of General Haushofer, by Andreas Dorpalen. Cloth. VII chapters, 331 pages. 15×21.5 cm. Farrar and Rhinehart Inc., New York. 1943. $3.50.

Selections from the German Zeitschrift für Geopolitik and the analysis of such phases of geopolitiks as Ratzel's Space Concept; Urbanization a Manometer; Space and Power; Geopolitiks Solves all Boundary Problems; The Airplane as a Geopolitical Force.

The New World, by Isaiah Bowman, President of Johns Hopkins University. Cloth. XXXV chapters, 605 pages, 257 maps and illustrations. 17×24.5 cm. World Book Company, New York. 1928. $6.00.

World problems presented by a master American geographer whose work Haushofer has tried to refute. The facts are clearly marshaled and given systematic analysis. A formidable array of geographical facts and ideas of world wide application. A necessary source to give the political aspect of many of the present world geographical problems.

The Earth and State; A Study of Political Geography, by Derwent S. Whittlesey, Professor of Geography at Harvard University. Cloth. XVIII chapters, 392 pages and 85 maps. 16.5×24 cm, Henry Holt & Co., New York, 1939. $3.00.

A political geography by an American who gives attention to the human effort in adjusting to the geographical conditions. World wide in application.

Geopolitics, by Robert Straus-Hupe. Cloth. XVII chapters, 267 pages, 3 maps. 21×15 cm. Putnam, New York. 1942. $3.00.

The origin of Geopolitik in the works of Ratzel, Naumann and the Swedish Kjellen. The gradual shaping of the present Geopolitik creed by Haushofer for world conquest. A full discussion of the Heartland and the technical advances in transportation that have wrought revolutionary changes in the relationship of nations.

The United States at War, by T. A. Bisson and others. Foreign Policy Report, Vol. XVII, No. 20, Jan., 1942, pp. 290. Clear statements as to the purposes of each nation concerned in the war and the part played by each in their geographical sphere.

Democratic Ideals and Reality, by Halford J. Mackinder, formerly Professor at Oxford and the University of London. Cloth. VIII chapters, 209 pages. 19×13.5 cm. Henry Holt and Company, New York. 1919. $2.00.

Written by the English geographer in 1919. Its ideas eagerly taken up by the Haushofer school and bent to suit their ideas of world conquest. Mackinder's brief summary is still worthy of careful reading and his little rhyme sums up the idea of world conquest that Haushofer has developed.

"Who rules East Europe commands the Heartland;
Who rules the Heartland commands the World-Island;
Who rules the World-Island commands the World."

America and the Race for World Dominion, by Albert Demangeon, Professor of Geography at the Sorbonne, Paris. Cloth. VIII chapters, 231 pages. 21.5×14.5 cm. Doubleday, Page & Co., Garden City, N. Y. 1921. $1.60.

Published by the famous French geographer as "Le Declin De L'Europe" and translated under the above title. An economic geographical interpretation of world changes due to the expansion of the United States and Japan. A pointed discussion of Europe's decline to a "little cape of the great continent of Asia." Excellent for its clear interpretation of geopolitical conditions.

Geography and World Power, by James Fairgrive, Professor in the University of London, England. Cloth. XXVIII chapters, 341 pages, and sketch maps. 18.5×13 cm. E. P. Dutton & Company, New York. 1917. $1.50.

A clear review of the world's geographical conditions that have set the stage for the evolution of nations. Much quoted by Haushofer in various geographical articles.

Atlas of Today and Tomorrow, by Rado and Rajchman. Cloth. 93 pages of text and 209 maps. 26×21 cm. Gollancz. London. 1938. $3.00.

Excellent diagrammatic maps showing the world struggle for colonies, markets and communications, as well as problems of nationality, religions and races. A useful display of the present world conditions.

The Strategy of Raw Materials, by Brooks Emeny. Cloth. XI chapters, 202 pages. 15×21.5 cm. Macmillan Company, New York. 1934. $1.60.

A clear summary of the world's raw materials and their importance in the peace and war of the world.

Strategic Materials in Hemisphere Defense, by Hessel, Murphy and Hessel. Cloth. X chapters, 224 pages and many pictographs. 14.5×21.5 cm. Hastings House, New York. 1942. $2.50.

A clear summary of the world's raw materials essential in war and their production by countries. Accompanied by the latest available tables of statistics and well illustrated by useful pictographs. The analysis of the present world condition regarding raw materials is concise and clear.

Strategic Materials and National Strength, by Harry N. Holmes. Cloth. XII chapters. 101 pages. 21.5×14.5 cm. Macmillan Company, New York. 1942. $1.40.

Shows the uses of thirty important raw materials in the present war The exact position of the United States in regard to resources of each of these vital materials is clearly stated.

Human Geography in the Air Age, by George T. Renner, Professor of Geography at Columbia University. Cloth. IX chapters, 283 pages, 55 illustrations mostly sketches. 22×14 cm. Macmillan Company, New York. 1942. 66 cents.

A compact summary of air transportation and its influence on world condititions. Plenty of clever and stimulating ideas that need testing.

Global War; An Atlas of War Strategy, by Edgar Ansel Mowrer and Marthe Rajchman. Introduction by Honorable Frank Knox, Secretary of Navy. Paper. IV chapters, 126 pages and 82 maps. 26×21 cm. William Morrow and Company, New York, N. Y. 1942. 60 cents.

Am ambitious atlas. Simple presentation of the global geography of the present war. Its material might be easily adapted to the secondary school. Plenty of material to aid the geographical understanding of the war.

HOUSING UNITS

Mobile housing units, each providing 250 square feet of floor space, fold into packages 16½ feet long, 8 feet wide and 26 inches thick. They use an accordion-opening technique and may be erected in a few minutes.

NOTES FROM A MATHEMATICS CLASSROOM

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(*Continued from the October issue*)

58. Intelligent Checking. Should a pupil in an algebra class check the solution of every equation that he solves? By checking I mean the substitution of the supposed value of x in the original equation? Teachers would doubtless answer "not every." Should the pupil check fifty per cent of the solutions, or twenty per cent? My answer is "About ten per cent."

When teaching the multiplication of $2x^2-5x+9$ by $3x-5$ should the answer be checked by substituting some value for x in the factors and in the product? When learning long division should the work be checked by substituting some value for x in the dividend, divisor, and quotient?

My answer to all such questions is a firm *No*. I would check one such example on the day when the process is first taught, but this is done merely to remind the pupil that he is dealing with numbers not with letters of the alphabet. If my life depended on the correctness of an answer I would check a product by interchanging the factors, and I would check a quotient by dividing the dividend by the quotient or by multiplying the quotient by the divisor. My objection to checking any of this work by the substitution of a number is that it takes time which the pupil could spend better by working some more problems, and, second, there is no guarantee that the arithmetic will be more accurate than the algebra. As each new type of equation is introduced I favor checking the first half dozen of the equations, but this is done to reteach the meaning of the word *solution*.

Many teachers, who favor the checking by the substitution of a number, do so under the impression that they are keeping alive the pupil's skill in arithmetic and are also coordinating arithmetic and algebra. But they are keeping alive only the pupil's skill in adding, subtracting, multiplying and dividing. Arithmetic, in any grade, should consist of a great deal more than ability to compute even if the operations include work on fractions, decimals, and per cents.

59. Arithmetic in the Algebra Class. If the arithmetic in the algebra classes is to be more than drill in computing, what

should be its nature? I shall present a few examples to indicate the possibilities. Consider the problem:

A canoe has a triangular sail; the base of the triangle is 9 ft., and the altitude is 7 ft. If the pressure of the wind is $2\frac{1}{2}$ lb. a square foot, what is the total pressure on the sail?

The problem appears to offer little more than the application of a simple formula and, as such, the problem appears to be just some more drill in computing. But let us watch a pupil solve this problem at the blackboard. He multiples 9 by 7 and divides by 2, getting $31\frac{1}{2}$; and then he multiplies $31\frac{1}{2}$ by $2\frac{1}{2}$. Perhaps he changes the factors to 63/2 and to 5/2. What is the profit in dividing 63 by 2 and then changing $31\frac{1}{2}$ to 63/2? The problem for the class to discuss is not *What is the pressure?* but *Has the work been done intelligently?*

The discussion should bring out:

1. Before doing the computing in a problem, plan *all* the work. Indicate what you plan to do before you do it. In this case,

Area $= \frac{1}{2} \times 9 \times 7$

Pressure $= \frac{1}{2} \times 9 \times 7 \times 2\frac{1}{2}$

2. The commutative and associative laws for multiplication state that the multiplications may be performed in various ways; and, in most problems, one order may be easier than some other. (The words commutative and associative need not be used.) After explaining the possibilities, the teacher should write on the board a few exercises like:

$\frac{1}{2} \times 37\frac{1}{4} \times 50$ $\quad$ $1/3 \times 2\frac{1}{4} \times 18$ $\quad$ $4\frac{1}{2} \times 12 \times 5/6$

asking, not that the computations be performed, but what is the best order in which to do the multiplying? In all such work the teacher should be thinking: For what can I use this problem besides as an exercise in computing?

As a second example, suppose the class is about to study a problem like:

A man invests part of \$5000 at 6% and the remainder at 3%. If the total income from the investments is \$210, how much is invested at each rate?

A good introduction to this problem is:

A man invests \$1000 at 6% and \$4000 at 3%. What is the average rate of income on his investments?

This is a problem in arithmetic and no algebra should be used except perhaps in answering the question: 180 is what per cent of 5000? The class should solve not only this *one* arithmetic problem but should discuss what happens if the \$5000 were split

into \$2000 at 6% and \$3000 at 3%, and if split into \$3000 at 6% and \$2000 at 3%, and so forth. From these problems the pupils should get not only practice in computing but also certain other ideas, such as:

1. The average *depends* on how the money is divided.
2. The average lies *between* the two given per cents.
3. The average is *closer* to that one of the given per cents which is associated with the larger investment.

A similar problem, which has the advantage of not involving per cents, is:

If 60 bu. of corn worth 90¢ a bu. and 40 bu. of wheat worth \$1.20 a bu., are mixed, what is the value of the mixture per bushel?

If the mixture is kept to 100 bu. and various amounts of corn and wheat are used, then conclusions similar to those above can be reached. Other types of mixture problems can be handled in the same way.

One more example will show the many possibilities.

If wheat loses 18% of its weight in a grinding process, what was the original weight of some wheat which weighed 1640 lb. after grinding?

This problem, typical of algebra, involves four numbers: the original weight, w; the per cent of loss, p; the actual loss, l; and the final weight, f. Now propose these questions:

If one of the four numbers is given, can you find the other three numbers? If two of the four are given, can you find the other two? If three are given, can you find the fourth?

When two of the numbers are given, can you choose these in any manner, or are they in any way dependent? When three are given, are there restrictions on the choice? How many different kinds of problems are possible?

The chief trouble with this problem is that it suggests so many possibilities that it is difficult to make the class let go of it and return to the customary algebra. Finally, I suggest as a good subject for a doctor's thesis: A study of the teaching of arithmetic in algebra classes. What can be done? What should be done? What is being done? If the thesis has already been written, I am interested in hearing about it.

60. Algebra in the Geometry Class. The previous paragraphs suggest a related topic: How much and what algebra should be included in a geometry class? Many of the new text books in geometry include review or maintenance work in algebra. The

object is mainly to keep alive the pupil's ninth grade skill with operations and with the solution of typical algebraic problems. I see little reason for doing this unless (a) the pupil expects to take some examination covering both algebra and geometry at the end of the geometry course, or (b) the pupil will continue into intermediate algebra in the eleventh grade and the teacher hopes to avoid some review work in that course, or (c) the work in algebra and geometry can be coordinated. By (c) I mean that we can present problems which can best be solved by a combination of the tools of both algebra and geometry.

We are not using algebra in a geometry class merely because we denote a line by l instead of by AB; neither are we using algebra because we call an angle m instead of CAB. Nor are we enlarging or perpetuating the pupil's understanding of algebra merely by introducing a problem like:

Find two angles which are supplementary and differ by 30°.

I doubt whether algebra can contribute much of anything to the work of Book One or Two of geometry. In Book Three, and thereafter, there are possibilities. The work on proportions obviously lends itself to the use of equations, and the work is valuable if the problems are generalized. The class should solve:

The sides of a triangle are 8, 10, and 12. Find the segments of the largest side made by the bisector of the opposite angle.

The class should also solve:

The sides of a triangle are a, b, and c. Find the segments of the side a made by the bisector of the opposite angle.

Likewise, the work on the Pythagorean theorem and on the areas of regular polygons should include a review and extension of the work on radicals. The other parts of algebra may well hibernate. Hibernation has its good points. Consider the perennials in the fields and how quickly they revive after a winter's rest. If I seem to be dogmatic in these statements I excuse myself on the grounds that these notes are expressions of my experience.

ENGINE CONTROL IMPROVED

An improved method of speed control and synchronization of engines on multi-motored aircraft has been invented by Erle Martin and Frank W. Caldwell of Hartford, Conn., who assign their patent rights (no. 2,330,070) to the United Aircraft Corporation.

From a single control lever, the speed of the engines can be varied at will and they are kept running in harmony at any selected speed. The electrically operated device can also be adapted to other vehicles powered by more than one engine.

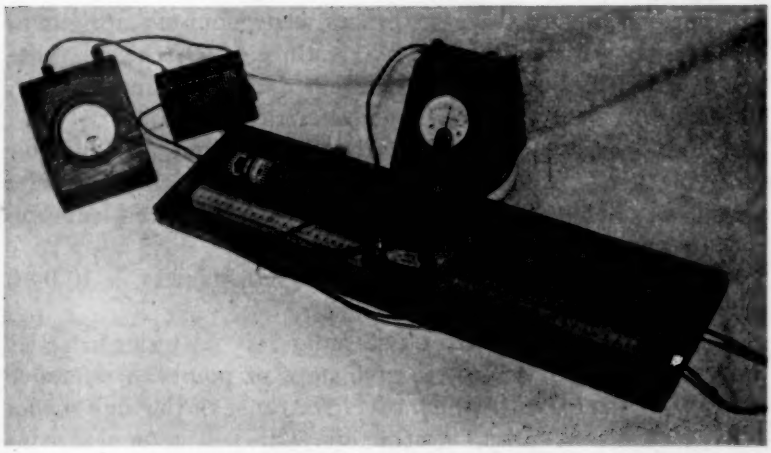
CHECK YOUR VOLTMETER

A HIGH SCHOOL LABORATORY EXPERIMENT

JOSEPH A. MACK
McBride High School, St. Louis, Missouri

What greater thrill can the harassed pupil have than in turn to sit in judgment on his tormentor? When pupils in an elementary physics course have been dogged for months with that Sword of Damocles of "percent error," they are almost ripe for revolt. When they even become willing to call into question the accuracy of their electrical meters, that is the time to insert the experiments on the calibration of voltmeter and ammeter.

Checking the accuracy of the voltmeter with a potentiometer is nothing new. The commercially available ones are always expensive, and therefore limited in number in any laboratory. The types of potentiometers are varied, and the one herein described is but an adaptation of a suggestion found in *Laboratory Experiments in Elementary Physics* by Newton Henry Black (Macmil-



A potentiometer for checking the voltmeter.

lan, 1938). Only one of the science supply houses has a somewhat similar apparatus, and so priced, we found, as to be three times the cost of materials. To change the type of potentiometer found in the text would require added explanations and cut the already too short laboratory period still shorter. Thus we came to the decision to build our own model with N.Y.A. help, following

rather closely the model suggested in the text. Some of the changes we found advisable are:

1. A folded length for convenience of storage and handling.
2. Mounting of all parts on a single base.
3. Phone jack connections rather than a series of binding posts were used between unit resistors.
4. The use of a slide wire contact key similar to that used on a Wheatstone's Bridge.

Some of the details not easily recognizable either from photograph or from laboratory manual description are the following:

a. The 10 ohm coils are the commercial radio resistors, I R C, B.W. $\frac{1}{2}$ w. wire wound, sub-base mounted. The current carrying capacity of these resistors is ample if the limits of the test are not extended beyond 6 volts.

b. Phone tip jacks and phone tip plugs, Birnbach #407 and #415, were substituted for the series of binding posts between resistors, as a recognition of ease in handling as well as the elimination of most of the contact resistance.

c. Marked binding posts were installed where polarity is of consequence.

d. Two small metal corner braces were mounted upright to hold the substitute standard cell, a Burgess #2. One of these braces was drilled and tapped to admit a knurled thumb screw. This knurled screw assures perfect electrical contact.

e. Flexible test lead wires in red and black were used in color code; black to the black phone tip plug, red to the slide wire contact key. This slide wire contact key was borrowed from the Wheatstone's Bridge experiment.

f. Only available meters were employed, namely, a 10-0-10 milliammeter to serve as galvanometer.

g. As an unknown, one or two radio "C" batteries in series were used (Burgess #2370) to give steps or points of reference at $1\frac{1}{2}$, 3, $4\frac{1}{2}$, 6, etc. volts which cover the range of the high school laboratory direct current voltmeters. The voltmeter was connected across the "C" batteries' taps and read at the instant balance was reached on the potentiometer.

h. The slide wire (20 ohms per meter) and the half-meter scale are obtainable from apparatus supply houses.

i. The dimensions of the base are somewhat determined by the half-meter scale and the size of the single pole double throw switch to about 7×24 inches.

The total cost of materials was under six dollars. Encouraged

by the accuracy of the results obtained, the model was submitted to the Educational Electric Mfg. Co. of Vincennes, Indiana for duplication. This they contracted to do in the fall of 1939. Their product which differs only in non-essentials of trim is illustrated.

Within the limits of high school standards, the accuracy of results obtainable leaves nothing to be desired. Accurate two place decimal results are usual. The time of a trial at any voltage inclusive of the calculation time is about five minutes. By limiting the number of detached pieces, confusion of the student is decreased. Errors in connections are almost impossible, and the consequent ruination of batteries and meters is avoided. Further safeguards can be had by adding amateur radio name plates at the binding posts. The upkeep of the apparatus is one new substitute standard cell per year. To this must be added a new C battery every three years.

There is nothing difficult about the construction of the apparatus as may be seen from the fact that one of the private schools in St. Louis gave the construction of duplicates as a student project. The measurements obtained on such instruments were every bit as satisfactory as on commercially produced equipment.

A PLEDGE FOR PUPILS AND TEACHERS

To turn the trend, four Washington agencies called upon pupils, parents, employers, and local authorities to recognize the importance of "school first" for youth.

The Educational Policies Commission asked teachers and pupils to join in the following pledge:

As Students:

We will remain in school, attend regularly, and learn all we can, to make ourselves effective in the service of our country, remembering that this war calls for many skilled services on the battle front and at home.

We will safeguard our health and keep ourselves physically fit, so that we may be strong to perform our duties, remembering that preventable illness is a serious handicap to full wartime efficiency of the nation.

As Teachers:

We will provide a program of education and recreation for all youth, which will encourage them to continue in school and protect them from antisocial influences, remembering that they need to satisfy their desires for adventurous action and to feel that by continuing in school they can constantly grow in ability to render national service.

We will foster the physical and mental health of children and youth, and see that remediable defects are promptly corrected, remembering that the duties and strains of war require strong bodies and healthy minds.

A PROGRAM FOR IMPROVEMENT OF HIGH SCHOOL MATHEMATICS

WALTER H. CARNAHAN
Purdue University, Lafayette, Indiana

Walter H. Carnahan was chairman of the committee which planned the reorganization of high school mathematics for the war emergency in Indiana. He was then head of the department of mathematics at Shortridge High School, Indianapolis. Having been granted a leave of absence from that position, he joined the staff of Purdue University which institution makes available through the State Department of Education his services on a full time basis for conferring with high school teachers of mathematics and administrators on the improvement of teaching and the organization of mathematics.

It is a matter of common knowledge that far more than half of the men inducted into military service must make use of some amount of mathematics.[1] With the increased demands for the manufacture of arms, machines and instruments, it is evident that factory and shop workers will have equal or greater necessity for the use of mathematics. Many of these workers are and will continue to be women. It seems evident, then, that some mathematical training for women is fully as important as for men. The complaint has been loudly voiced and often repeated that mathematical training both for men and women is now seriously inadequate. While there is some evidence that the defects are not so serious as sometimes asserted to be,[2] yet they are so prevalent as to constitute a recognizable handicap wherever any mathematics is called for.

The need for scientific training is almost as great as for mathematical training, and the deficiency is as noticeable. Some knowledge of elementary physics is required in many branches of military and civil activity. It is obvious that any understanding of physics involves an understanding of elementary algebra, arithmetic and geometry.

Since most boys enter military service and many girls enter offices, shops and factories at eighteen years of age, there can be no debate as to whose is the responsibility for making such improvements in mathematical skills as are possible. It is the obligation of the high school teachers and administrators. We live in a democracy, so no one says we *must* take steps to cor-

[1] Somervell, Gen. B. B., in a speech to educators Aug. 28, 1942.

[2] Hart, William L., "Short Term and Long Term Effects of the War on the Secondary Curriculum in Mathematics," SCHOOL SCIENCE AND MATHEMATICS, June 1943.

rect the difficulty, but the compulsion of obvious duty is sufficient. We are all looking for ways in which we can make some contribution to the improvement of the situation, and suggestions come from all sides. These range from, "Go on as you are now going, nothing needs to be done," to "Toss all previous mathematics courses out the window and organize purely war courses." It is the opinion of the writer that somewhere between these extremes lies the desirable median. It is the purpose of this article to attempt to indicate just where the writer thinks the median lies and what organizational readjustments are needed.

During the last year, the writer has called on many teachers of college and university science and mathematics as well as on many high school teachers. He has held many conferences over the state of Indiana in an attempt to learn what teachers think needs to be done as well as to try to influence their thinking. Out of these conversations and conferences have been gleaned many ideas that point the way toward a workable program for the improvement of high school mathematics. They are not ideas that are original with the writer nor new to the thinking of mathematics teachers, but they can claim the sanction of evaluated experience. As to the program of improvement based on these fundamental ideas, it may be pointed out that this is not untried, although it cannot be claimed that it represents the experience of the majority of high school teachers in Indiana, chiefly because many of its features are obviously not applicable to smaller schools.

Do Not Take the Attitude that Mathematics Is the Only Important Subject or the Most Important Subject in the High School Curriculum. Even for a scientist or an engineer, the ability to read with understanding, for example, is equally as important as mathematics. And a successful engineer once said that the inability to speak in public constituted one of his principal handicaps. So far as mental discipline is concerned, the study of foreign language, even an ancient language, makes much the same contribution as the study of mathematics. As teachers of mathematics, our attitude should be that, culturally and practically, mathematics is just as important as other subjects for good students and weak alike, each within the limits of his ability and probable experience, and it is no more important than these.

Knowledge and Skills Worth Acquiring Are Worth Retaining. Fortunately, no one doubts this assertion. The only point that

needs to be emphasized here is that retention of knowledge and skills is not automatic. If there is to be retention, it must be specifically planned for and worked for. This means reteaching and drill. This takes time that we would perhaps prefer to devote to other things, but it is time well spent, and in fact it seems obvious that to use this time for other things is to misappropriate it. In the first year algebra course, there should be a constant reteaching and review of the fundamentals of arithmetic, and in geometry there should be a review of both arithmetic and simple algebra. These reviews should be integrated with the new material as closely as possible, but most texts leave this integration for the teacher.

Teach for Understanding Rather than for Facile Manipulation. Two university students were working together in a class in science. The problem involved adding $\frac{1}{2}$ and $\frac{1}{3}$. One said the answer was $\frac{2}{5}$ because $1+1=2$, and $2+3=5$. The other said the answer was $\frac{1}{6}$ because $1\times1=1$, and $2\times3=6$. Each one said "That is the way I remember the rule." Neither had learned to do the operation by the application of fundamental principles, but by remembering a rule. Note that we do not say they had been *taught* to do it by rule; the probability is that they had been well taught except for the final step in teaching which is to insist that fundamental principles be habitually employed rather than allowing manipulation without understanding. It is one of the most frequently voiced complaints by college instructors in mathematics and science that students do not understand the processes they must perform.

Do not Try to Cover too Much Territory in a Given Time. This is a corollary to teaching for understanding and retention. It takes time to see that fundamental processes are learned and habitually used, and it takes time to review and drill. This means that fewer topics will be taught, or fewer problems will be solved, or both. But for any use to which mathematics is to be put, there can be no doubt that emphasis on understanding and retention pay dividends. College and university instructors are almost unanimous in saying that high school teachers attempt to teach too much.

A word of caution here: There is no merit in reducing the content of any course just for the sake of slowness. On the contrary, teach every topic and do as many exercises as possible, subject only to the necessity to be thorough and to take only a just portion of the time of pupils.

Teach Pupils to Read Mathematics with Understanding. If there is a universal complaint voiced by teachers of high school and college mathematics alike, it is that pupils cannot read with understanding. There is no gain in saying that the teacher of reading has done a poor job; we all know remedial teaching of reading must be done, and the mathematics teacher will probably have to do it, at least under present prevailing circumstances. The fact seems to be that ability to read history or poetry does not imply ability to read mathematics. The mathematics teacher will need to plan to teach pupils to read algebra and geometry. And this teaching is not done once and finally, say during the first three days of a semester. It is a program that must be made continuous. And again it should be pointed out that this is not time wasted; progress will be more rapid if time is taken to master this fundamental ability.

Teach Pupils to Get Pleasure out of Hard Work. But whether or not they get pleasure out of it, hard work is salutary and an integral part of the process of education. The phrase, "Blood, sweat and tears," is new but the philosophy is as old as Christianity, or older. Too many pupils in high school are missing the fundamental joy that comes from mastery at the expense of exertion. We should more often say to pupils. "This topic is not easy; you may find it downright hard. But see if you are equal to it." Often the reaction to this appeal is much better than to the assertion that "this is easy; you can do it in no time."

Checking Should Become Habitual. This will tend to make pupils more self reliant and reliable in their work. It is debatable whether texts should contain the answers to all, or part, or none of the problems. But the habit of applying a check of some sort to every result should be cultivated. This check should be applied whether or not there are book answers. Again it must be admitted that checking takes time, and not so many topics can be covered nor so many exercises worked as when no check is required, but the value of checking is worth this price.

Teach Mathematics as a Functional Subject. There are a few persons who are interested in mathematics without any concern for its applications, but these persons are comparatively few. Most persons who are interested in the subject are interested because of the things one can do with it. Particularly is this true of persons of high school age. But aside from present interest, the fact is that nearly all will have occasion to use mathematics in buying and selling, in drafting, in studying

physics. These and other applications of the subject should not be slighted. Verbal problems within the limit of the ability of the pupils constitute one of the best ways of giving the functional slant to mathematics, and, troublesome as these are, they should receive emphasis.

Encourage Capable Pupils to Take all the Mathematics Offered in the High School. Science, engineering, military activities, invention, industry are certainly going to become more and more mathematical. Those who have part in their development and those who will only interpret and use them will need to know the language in which their laws are expressed. That means increasing dependence on mathematics and increasing power in the hands of those who know it.

High School Mathematics Sequences. In general there are three types of pupils in high schools whose mathematical needs should be considered: (a) there are those whose interests are vocational; (b) there are those whose interests are those of the consumer; (c) there are those whose interests are cultural or professional. So far as circumstances permit, the needs of these three groups should be provided for by three different mathematics sequences. Not every school will have any considerable number of pupils whose interests are vocational, but every school will have representatives of the other two groups. For group (a) there should be a vocational mathematics sequence. For group (c) the traditional high school mathematics sequence[3] is still the best that has been suggested. For group (b) there should be a sequence presenting elementary general mathematics and consumer arithmetic.

The Vocational Mathematics Sequence. In this connection the word sequence is not meant to convey the idea that there is a general organization of mathematics material for vocational pupils and an order in which it should be studied. The plumber needs one kind of mathematics, the tin smith needs another, and the electrician needs still another. Only the teachers of the special courses could plan the mathematics to be taught to the various classes, and perhaps only they can successfully teach it. Consequently, we shall make no suggestions concerning the content and teaching of such courses.

The Consumer Mathematics Sequence. By consumer we mean

[3] By *sequence* as here used, we do not mean so much the order in which subjects should be presented as the amount of subject matter to be presented in the courses. In other words, subject matter may be organized on the unified basis or on the isolated basis.

the person who will buy clothing and food for a family, take out insurance, operate a car, pay taxes, take a family to the moving picture show, make a trellis for the roses, paint the floor, replace a broken window pane, plan for a vacation, go to the dentist and doctor, live intimately with electrical and mechanical devices. He will need to know a little about arithmetic, a little about geometry, a little about algebra, a little about the applications of each of these subjects to the situations with which he will have to deal throughout life. For this group, it seems that a year of elementary general mathematics and a year of consumer arithmetic are obviously indicated. By this, I do not mean that two years of mathematics should be required, but that if two years are taken, they should include the subjects named.

The Traditional Mathematics Sequence. The complete sequence should include a year of beginning algebra, a year of plane geometry, a full year of advanced algebra, a half year of solid geometry, a half year of trigonometry, a half year of college algebra, and a half year of the mathematics of finance. Some schools now offer a year of mathematical analysis or senior mathematics rather than a half year of trigonometry and a half year of college algebra. Of course, not many schools can offer this complete sequence, and where it is offered, not many pupils can take all that is offered. Certain details of this sequence call for brief discussion.

Advanced High School Algebra. It is generally agreed that it is impossible to teach well in one semester the material presented in the usual second course algebra text. The teacher has choice of "hitting the high spots" and sacrificing mastery, or doing a part of the work thoroughly and leaving much of it untouched. The choice here should be an easy one: Do thoroughly as much as possible and not be concerned with the rest. But a better plan is to take a full year for the course and use a supplementary problem book to give additional practice. Experience proves that the results of such an organization amply justify the added time required.

Solid Geometry. It is believed that the year of formal logic in plane geometry is time well spent, but it is believed that in solid geometry there is more profit in emphasizing problem solving and reducing the amount of proof to a minimum. This suggestion is in line with the recommendation of The National Committee on Mathematical Requirements, The State Educa-

tion Department of New York, and many other authorities.

Mathematics of Finance. Schools are sometimes criticized because it is believed that the traditional mathematics organization takes into account only the interests of scientists, engineers and technicians and neglects the interests of those who will make use of their mathematics in economics, finance and related subjects. To provide for this group of people, it is suggested that a course in elementary mathematics of finance be offered where circumstances permit.

Mathematics Refresher Course. Complaints from the military authorities and employers regarding the lack of mathematical preparation of young men and women have resulted in a wide spread program of remedial courses given to seniors. There have been many suggestions that this is too valuable a feature to discard when the war has ended. Whether or not this becomes a permanent part of the educational program, it is generally believed that it must stay during the emergency. The common practice is to test all seniors for retention of the essentials of arithmetic, and give two days a week review to those who show serious deficiencies. Many schools give the course five days a week and include some simple algebra and intuitive geometry as well as arithmetic.

Sequence Variations Due to War Needs. The writer is not acquainted with any statement issued by military authorities which suggests that we should do great violence to the reorganization of high school mathematics. Their plea generally is that we teach for more mastery of the fundamentals. The mathematics we now teach is wholly satisfactory in kind but not in quality. There is no call to discard present courses in mathematics and science and try to find stream-lined substitutes. However, in making choice as to which of two courses to offer when both cannot be given, or which to recommend to a pupil when he has not time for both it may be advisable to choose a sequence which in peace times would not be regarded as best. For example, a senior boy can take fourth semester algebra or trigonometry, but not both. Ordinarily it seems the choice should be algebra and let him take trigonometry in college, but just now it would seem best to recommend the trigonometry.

Teacher Conferences. A final word in regard to professional meetings: This is not the time to abandon these. Changes are taking place all around us. Every one wants to do what he can to make necessary readjustments. It is no time for you and me

to go alone. We must get together to exchange ideas and to formulate effective plans. This does not mean that we must go a long way from home or wait for someone to announce a big conference. Get together in small groups, counties, or cities, or districts, sit down together and evaluate suggestions made by others, and formulate plans for local procedure. Read your professional magazines and books. During the war and after it is over, let us make mathematics a more effective part of the educational program.

SCIENCE EDUCATION AT THE JUNIOR-HIGH-SCHOOL LEVEL DURING THE COLONIAL PERIOD

HEBER ELIOT RUMBLE
Havana Community High School, Havana, Illinois

It has been ascertained that science education at the junior-high-school level in academies, town schools and district schools of the early decades of our national history was an actuality.[1] Academies, however, did not appear until after the establishment of the Philadelphia Academy in 1751, and did not become popular until the last quarter of the eighteenth century; and reliable historians have shown that science education was not offered in the town or district schools of the colonial period. Were colonial youth of junior-high-school age ignorant of scientific facts and principles? Or were there other institutions of the colonial period that provided science education for youth of junior-high-school age? Since there is always the tendency for cultural continuity to go on—even to survive revolution—the historian interested in the origins of science education at the junior-high-school level must not be satisfied with an examination of abbreviated curricula of the late eighteenth century but also must scrutinize certain practices and ideas of culture handed down from generation to generation during the colonial period.

While it is true that only a small proportion of colonial people was directly touched by education, it is equally true that much of what the college students learned came to the attention of the people by way of college-educated schoolmasters and ministers,

[1] See Heber Eliot Rumble, "Science Education at the Junior-High-School Level, *Circa* 1776–1827", SCHOOL SCIENCE AND MATHEMATICS, 42: 724–728, November, 1942.

and the writings of college graduates. The data show that soon after the middle of the seventeenth century the students at Harvard, e.g., were making fun of scholastic physics in their theses, that they had heard of the "new astronomy," and that the pseudo-science of astrology was a favorite butt of undergraduate disputants at commencement time. An examination of Harvard thesis titles shows that there was considerable interest in scientific topics at this institution. Harvard students, after 1672, made use of a three-and-a-half-inch telescope, which had been presented to the college by John Winthrop, himself interested in almost every branch of science.

In 1663 Increase Mather, Samuel Willard, and a number of other Boston gentlemen founded a scientific club, the Philosophical Society, and met fortnightly for a number of years discussing problems in natural philosophy. That there were public lectures on scientific subjects during the colonial period is indicated by announcements appearing in colonial newspapers. The probability that some children of junior-high-school age attended these lectures is worth considering. The scientific production of colonial America may have been comparatively negligible, yet it is to be weighed that many colonial men were elected fellows of the Royal Society of London, the great scientific academy of the English-speaking world. Morison lists one member from the Carolinas, three from Virginia, three from Pennsylvania (including Benjamin Franklin), and eleven from New England—the list not including Governor Fauquier of Virginia, who was elected before he came to America.[2]

Apprenticeship was the most fundamental institution of the colonial period. Apprenticing of children usually occurred by the time they were thirteen or fourteen years of age. Many children of junior-high-school age were taught trades, as apprentices, which must have involved the learning, understanding, and appreciation of some facts and principles of science. Although too much must not be read into the act, it is interesting to note that in 1660 Boston passed an apprenticeship law which began as follows:

> 20th., 6th mo., 1660. Att a Towne's meeting . . .
> Whereas itt is found by sad experience that youthes of this town, beinge put forth Apprentices to severall manufactures and sciences, . . .

Unapprenticed children, too, doubtless learned many scientific

[2] See Samuel Eliot Morison, *The Puritan Pronaos* (New York: New York University Press, 1936), pp. 234–266, for a reliable description of "colonial scientific strivings."

facts and principles while carrying out their usual chores. For example, the son of the plantation owner, even as a boy, accompanied the overseer on his rounds and learned countless things that had to be done in conducting the estate, such as how to cultivate grapes, plant and care for corn, raise and cure tobacco, and many similar seasonal activities. The children of artisans learned while working with their parents. Paul Revere must have learned many skills involving a knowledge of scientific facts and principles while working in his father's shop, to become colonial America's finest silversmith (and later the maker of amalgams used in the manufacture of ship gear). We know that the making of medicines from herbs, soap-boiling, cheese-making, tinkering, and many other skills involving the use of certain scientific facts and principles were learned at home or through apprenticeship.

Many boys who attended Latin grammar schools did so with the intention of preparing for college; many more attended those schools for the purpose of obtaining a general education. The boys remained in the grammar schools until fourteen or fifteen years of age. There was no science taught in the Latin grammar schools, but schoolmasters' accounts indicate that certain of the Latin authors who wrote on science were recommended to the boys by their teachers for outside reading. Pliny (the Elder) and Lucretius must have been read by many Latin-grammar-school boys upon recommendation by their masters. Pliny's *Natural History* treats of physics and astronomy, of geography, the animal kingdom and plants, mineralogy and the medicinal uses of minerals. Lucretius' *On the Nature of Things* demonstrates by argument the infinity of the Universe in space and time, and the infinity of matter. The fifth book of the work treats of astronomy, the history of the globe, and the origin of life and civilization. The colonial boy may not have studied a unit on *the water cycle* but he read how "uprise together, . . . full many seeds of water," how "the rainy moisture thickens into being in the lofty clouds," and how the water was finally "discharged in down-pour of large showers." Classical authors other than Pliny and Lucretius included elements of science in their writings, and they may have been read by colonial youth. Ovid's *The Fasti* brings in a certain amount of astronomical information, and his "The Creation" makes interesting reading. Seneca's *Quaestiones Naturales* is literally full of speculation upon the physical world. The reader is reminded of junior-high-

school science material when he reads Seneca's discussion concerning the wind. To the definition ,"WIND is the atmosphere in motion" Seneca would add, "in one direction." This seems more accurate, he says, because "the atmosphere is never so still as not to be in agitation of some kind."[3]

There were many private schools, particularly in seaport towns, during the colonial period that were open to students of any and all ages (who could pay the fees) and offering instruction in the sciences. Courses were planned with the knowledge that the master's livelihood depended on their meeting the needs of his students. A knowledge of geography and astronomy was necessary for the navigator; youth interested in navigation were taught geography and astronomy. School announcements appearing in newspapers of the colonial period, such as the *Boston News Letter*, *New York Gazette*, and the *Pennsylvania Gazette*, indicate that both geography and astronomy were popular subjects of instruction in the private schools of colonial America. In the private schools of colonial Boston were taught astronomy, geography, natural philosophy, optics, calculation of eclipses, the use of globes, and other science subjects. Many private schools were open during the early evening hours (and therefore referred to as "evening schools") to offer instruction to those unable to attend during the daytime. The evening schools offered the science subjects to all who wished to study them. To what extent students of junior-high-school age studied the sciences in the private schools is not known, but it is entirely probable that many did take advantage of the opportunity.[4]

We must conclude that many colonial children of junior-high-school age undoubtedly became acquainted with elements of science by way of (1) conversation, lectures, and writings of college graduates (particularly schoolmasters and ministers), (2) home and apprenticeship education, (3) writings of classical authors recommended by Latin-grammar-school masters for outside-of-school reading, and (4) private school instruction.

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[3] Robert Francis Seybolt, dependable authority on colonial education, has stated in lectures that data found by him indicate that Latin authors were recommended to Latin grammar school boys by their masters for out-side-of-school reading, whose works contained science material.

[4] Reliable material on science offerings of the colonial private schools is to be found in the following publications by Robert Francis Seybolt: "Notes on the Curriculum in Colonial America," *Journal of Educational Research*, 12: 279, November, 1925; *The Private Schools of Colonial Boston* (Cambridge, Mass., 1935), pp. 83–87, 92; *Some Source Studies in American Colonial Education: The Private School* (Urbana, Illinois, 1925), pp. 35, 41–42, 62–65, 68; and *The Evening School in Colonial America* (Urbana, Illinois, 1925), pp. 32, 58.

SCIENCE CONTENT IN THE ELEMENTARY SCHOOL

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Science in the elementary school is a comparatively new field. Until recently it was referred to as nature study and was given an inconspicuous place in the curriculum. It was taught only incidentally in many schools and all too frequently consisted of memorizing unrelated details. Little attempt was made to present it in an organized way or to stress the interrelationships which lend meaning to science. Today, when science is playing a larger role in human life than perhaps at any other period, it is being humanized and brought closer to the daily life of the children. Science is being recognized as a broad subject, embodying the universe and the many things in it.

A review of the literature in the field shows that schools are interested in revising their present programs and in developing effective programs of science. Considerable study has been given to the matter of desirable content and the first question which confronts the educator who wishes to undertake a program of revision is, just what do our curricula contain? As an answer to this question, a survey of thirty courses, was made to find what topics in the fields of science were being presented in our elementary schools and at what grade level or levels they are placed. The courses were procured from various geographical areas and thus, they may be considered representative of the total conditions.

Each individual topic which occurred in a course of study was replaced in one of three fields of science, namely: Animal Studies, Plant Studies, and Physical-Chemical Studies, and in the grade in which it occurred in the course of study.

A total of 1,219 topics were found in the 30 courses which were examined, and the following general conclusions can be drawn from this study:

1. The large number of topics found indicates that there is a lack of agreement as to what should be included in the science curriculum of the elementary school. Only 23%, or less than one-fourth of the total number of animal topics occurred 10 or more times in the 30 courses of study, 28% occurred only once; 16%, or about one-sixth of the total number of plant topics occurred 10 or more times, 51% were mentioned once; 19%, or

approximately one-fifth of the physical-chemical studies occurred 10 or more times, 29% occurred only once.

2. There is no uniformity in placing the topics at grade levels; 557 of them occur in three or more of the six grades, 165 are listed in each grade.

3. The frequency of occurrence of each topic in any one grade is low; only 3.8% of the 1,219 topics listed in the entire study were found 10 or more times in any one grade.

4. There is difference of opinion as to whether the topic belongs in one of the primary grades, or in one of the intermediate grades, or in both. An average of 50% of the total number of topics occur at both primary and intermediate levels.

The following charts show the 25 topics in each field which have the greatest total frequency of occurrence.

Animal Studies

Topics	*Frequency of Occurrence* *Grades*						
	1	2	3	4	5	6	Total
Protection of birds by man	12	15	13	16	20	17	93
Ways birds are valuable to man	9	12	8	12	19	12	72
Migration of birds	12	15	9	7	17	12	72
Life history of toad or frog	15	22	9	6	5	3	60
Life history of honey bee	5	3	10	20	17	3	58
Farm animals	20	11	10	7	5	5	58
Life history of an ant	8	4	9	13	6	6	46
Life history of a butterfly	6	5	8	10	10	5	44
Habits of domesticated animals	10	6	10	5	4	4	39
Care of animal pets	19	7	5	3	3	2	39
Preparation of animals for winter	10	7	5	4	5	5	36
Life history of turtles	4	10	3	7	5	3	32
Life history of spiders	6	3	1	4	9	8	31
Home, habits, and food of rabbit	12	8	2	2	5	2	31
Life history of moth	4	3	4	6	8	4	29
Hibernation of animals	2	6	4	2	12	2	28
Domestication of animals	5	2	10	5	2	4	28
Changes in animal life because of seasonal changes in weather	5	8	6	3	3	3	28
Animals of the sea	2	6	5	9	2	2	26
Bird nests	2	5	5	7	3	4	26
Identification of common birds	5	5	3	5	3	4	25
Life history of grasshopper	5	4	5	5	3	3	25
Care animals give their young	7	5	8	2	1	2	25
Life history of snakes	1	4	5	6	5	3	24
Self-protection of animals	2	3	2	5	8	3	23

Although the figures shown indicate a lack of agreement among the makers of curricula as to the content and grade placement of our elementary science, a comparison of this survey with

Plant Studies

Topics	Frequency of Occurrence Grades						
	1	2	3	4	5	6	Total
Factors necessary for growth of plants..	15	9	10	9	10	3	56
Identification of common garden flowers	12	10	8	6	2	5	43
Green plants make their food.....	3	6	10	8	11	4	42
Seeds are scattered by wind.....	6	7	12	5	7	3	40
Seeds are scattered by birds and other animals.....	5	8	12	5	7	3	40
Seeds are scattered by water.....	5	7	12	5	6	3	38
Chemical changes which cause leaves to change color and to fall.....	17	8	4	4	3	1	37
Identification of common wild flowers..	8	6	10	5	3	4	36
Identification of common trees.....	10	8	4	6	4	3	35
Changes of plants in different seasons..	7	7	4	8	2	3	31
Reproduction of plants from bulbs....	8	8	3	3	5	4	31
Trees give us lumber.....	4	2	6	6	10	3	31
Seeds have structures that aid in seed dispersal.....	4	5	8	5	5	3	30
Formation and development of buds..	6	7	6	4	5	1	29
Food is stored in plants.....	3	4	8	4	5	1	25
Trees give us food.....	4	1	4	5	8	2	24
Identification of cedar tree.....	6	4	6	4	3	—	23
Identification of pine tree.....	6	3	6	3	3	—	21
Trees give us fuel.....	1	1	5	4	7	2	20
Trees beautify landscape.....	3	2	4	6	5	—	20
Parts of a flower.....	1	3	4	5	3	4	20
Trees give us paper.....	1	1	5	4	7	1	19
Need for conservation of trees.....	2	2	2	1	8	3	18
Trees give us clothing.....	1	1	3	4	7	2	18
Function of plant parts.....	2	3	3	3	3	4	18

a similar one made by Hillman[1] in 1924 reveals definite growth and changes in science curricula. From the topics listed in the existing courses of study in 1924, science consisted largely of the study of individual topics as such, without reference to their relation to each other or to life as a whole. Growth in the realization of the importance of the knowledge of scientific principles and the part science plays in the world is evidenced by the broader and more meaningful topics listed in this later survey. They show a definite expansion of thought along science lines. For example, the study "Usefulness of plants" in 1924 was confined to three uses: food for man, a source of clothing, and trees as ornaments. Now, listed under the same topic, in addition to the above three are: food for other animals as well as man; source of shelter, fuel, paper, tools, and medicine; homes for

[1] J. Hillman, "Some Aspects of Science in the Elementary Schools," *Peabody Contribution to Education*, Nos. 8–14 (Nashville: George Peabody College for Teachers, 1922.)

Physical-Chemical Studies

Topics	Frequency of Occurrence Grades						
	1	2	3	4	5	6	Total
Importance of the sun	17	19	23	20	6	5	90
Uses of water	5	11	10	18	4	12	60
Characteristics of magnets	3	15	8	10	4	18	58
Relation of time units to movement of earth	11	6	9	11	10	4	51
Location of constellations	4	4	8	12	9	12	49
Movements of the moon	3	5	4	16	14	5	47
Movements of the sun	20	6	6	5	6	4	47
Formation of rocks	3	8	11	12	6	6	46
Changes in surface of earth	—	2	6	11	4	22	45
Composition of air	7	5	4	10	8	4	38
Ways of producing electricity	—	—	—	11	9	18	38
Size of the sun	2	1	11	13	5	5	37
Length of shadows	13	8	7	4	3	2	37
Relation of moon to earth	5	3	4	7	7	10	36
Comparison of warm and cold air	2	1	3	9	12	9	36
Phases of the moon	8	6	5	7	3	5	34
Evaporation of water	8	7	5	5	5	3	33
Identification of planets	—	—	1	9	11	11	32
Characteristics of each season	9	6	8	2	4	2	31
Formation of soil	1	7	3	7	2	10	30
States of water: solid, liquid, and gas	2	5	6	8	3	2	26
Uses of electricity	—	7	1	5	1	12	26
Air pressure	—	1	—	7	7	8	23
Air occupies all space	6	1	3	6	5	2	23
Kinds of soil	1	4	3	5	3	6	22

animals; a record of the past; influence upon climate and effect upon health; prevention of erosion; provision for recreational centers. Another example is "Weather observation" found in 1924 versus "Importance of the sun" in 1942. Incidentally, the topics in the physical-chemical field indicate that one of the major interests in earlier science study was the weather. Further evidence of expansion is seen in the comparison of the single topic "Recognition of trees" which had the highest total frequency of all plant topics in 1924 and the single topic "Factors necessary for the growth of plants" which now leads in plant studies. "Birds" is the general topic in the animal field most frequently found in either survey. In 1924, emphasis was placed upon the single topic "Identification of birds," while in 1942 the most attention is given to "Protection of birds by man."

Science in the first six grades is no longer limited to a few isolated topics. The fact that it is derived from all the major science fields is shown by the enormous increase in the study of the earth, rocks, minerals, magnetism, and electricity.

The tables in the earlier survey contain no topics relating to the history of animal and plant life. There is no evidence that animals and plants were studied for their contribution to the records of the past. Necessity for the preservation of these forms of life is emphasized increasingly in the present courses of study.

The broader topics found in the later analysis contrasted with the correspondingly simple ones from earlier courses of study point to increased attention to the importance of the[2] "interrelationships of living things to living things and of living things to their physical environment."

As to grade placement of topics then and now, there has been a noticeable increase in frequency of topics occurring above the third grade, thus indicating, again, more extensive study in the science field.

This brief review of the content of the elementary science curricula shows that attention is being given this phase of our elementary education. However, science in the elementary grades is still in a transitional stage. There is a great need for further research in determining the basis for the selection and placement of topics in the science program. Shall it be built upon children's interests or upon adults' interests? Shall it be built upon social utility? Is there need for a new approach? What can we as teachers do to improve the science program in the elementary school?

[2] G. Craig, *Science for the Elementary School Teacher* (Ginn & Co., Chicago, 1940) p. 5.

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WATER IS COLORLESS

ARTHUR FURST
San Francisco Junior College, San Francisco, California

At times the chemistry teacher is called upon to give a short, entertaining lecture away from his own laboratory. Arriving at his destination, he may find none of the usual facilities, no outlets for bunsen burners, etc.; perhaps he may not even be permitted to use fire.

Many spectacular demonstrations can be found in color changes occurring in solutions which have the appearance of ordinary water. By mixing these seemingly colorless liquids, a variety of novel features, color effects, and surprises can be achieved.

No special chemicals are necessary. As a rule, the solutions need not be of any specific concentration. In the demonstration outlined below only two solutions require adjustment. It is, of course, a good idea to run through the demonstration beforehand to see if the solutions are as desired.

WATER IS COLORLESS

"Good evening, ladies and gentlemen. My topic this evening is the common, ordinary, everyday household necessity—*water*. Water has many well known characteristics which the chemist calls properties. These are, in the main, that water is colorless, tasteless, and odorless. I should like to discuss only one of these properties, viz: water is colorless. Before the evening is over, you will, I am sure, be glad I did not discuss the fact that water is odorless or tasteless."

"It will not take very long to prove that water is colorless." The demonstrator looks at his watch and starts to pour "water" from flask into "water" of beaker. Throughout this procedure the demonstrator must not watch the beaker. The solution in the beaker turns red, but before the last few c.c.'s are added, the solution is colorless again. When this has occurred, the demonstrator shakes beaker, steps back. "You see, water is colorless." (I)

"I have heard that milk contains water, but water is peculiar . . . Watch!" He pours two colorless solutions into pint milk bottle and "milk" is formed. Pour this "milk" into a beaker partly filled with "water." The "milk" becomes colorless. Pour

these contents into a quart milk bottle that is also partly filled with "water." The "milk" reappears. (II)

"Ladies and gentlemen, I still believe that water is colorless." As he talks, the demonstrator takes out a whiskey bottle filled with "whiskey," looks at it, shakes it—and the "whiskey" becomes colorless. (III)

"This lecture must be, to some, clear as mud." He pours two flasks of colorless "water" into a beaker; the "mud" appears. "Or am I underestimating my audience? Perhaps it is clear?" Pours "mud" into another beaker partly filled with "water," and "mud" clears. (IV)

"Speaking about mud, I wonder how water would act in a blackout?" Pours some "water" into a beaker containing "water." "Just what would water do when the siren starts shrieking?" Solution suddenly turns black. "What would happen if the "all clear" sounded?" Pours black water into beaker containing some colorless solution. As the black water flows into the beaker, it turns colorless. (V)

"It is hard at times to convince some people that water is colorless." Pours "water" of two flasks together. Liquid turns dark violet. "The tendency is to shake that person (shakes beaker), but the wise thing to do is to leave him alone. He will soon come around and see things your way." As the demonstrator talks, the solution becomes lighter and lighter, and then becomes colorless. (VI)

"In times like these, water also has a message to bring. It can express itself in three words (As the demonstrator speaks the three words, he pours some water from a flask into each of three beakers filled with 'water'): *Buy War Bonds.*" The first beaker becomes red, the second white, and the third blue. (VII)

Background of the Demonstrations

The method of preparing these solutions may vary according to the individual. The concentrations are given, but the demonstrator may adjust them to suit his own plans.

(I) Flask of "water" into beaker half full of "water": The flask contains 2M HCl to which 20 c.c. of phenolphthalein is added. The beaker contains 2M NaOH. (There should be about 50 c.c. less NaOH than HCl.)

(II) Milk demonstration:
The two flasks contain dilute solutions (0.1M) NaCl and $AgNO_3$ respectively. The beaker contains 1M NH_4OH. The quart bottle contains 2M HNO_3.

(III) Whiskey:
Dilute some tincture of iodine until it looks like whiskey. In the cork is a notch containing a crystal of sodium thiosulfate.

(IV) Clear as mud:
Silver nitrate 0.1M is contained in one flask, and 0.1M sodium hydroxide is contained in the other. The "mud" is poured into a beaker containing 2M HNO_3.

(V) Water during a blackout:
The beaker contains 0.02M solution of potassium iodate. The flask contains a solution made up as follows: (This must be a fresh solution): 1.26 g. of sodium sulfite, 15 g. of starch made into a paste with 100 c.c. of water, and sufficient standard acid to make 0.04M sulfuric acid. These solutions must be adjusted for time.
The black solution is poured into a 0.1M sodium thiosulfate solution, resulting in a colorless liquid.

(VI) Convincing experiment:
One flask contains a solution of ferric chloride; the other contains sodium thiosulfate. To speed up the clearing, a few drops of copper sulfate solution may be added to the ferric chloride. It is necessary to experiment by adding one drop at a time.

(VII) Buy War Bonds:
The first beaker contains a solution of potassium thiocyanate, the second silver nitrate, the third potassium ferrocyanide. The pouring flask contains ferric chloride.

FOOD FROM THE ALLIES TO FEED ITALY NEEDED THIS WINTER

The Allies are reported to be helping feed the Italian population now in areas from which the Germans have been driven, and will have to continue to do so until 1944 crops are harvested. This year's surplus olive oil, citrus products and sulfur may be used in payment, in part at least.

Italy's crops this year are reported good. The season has been favorable. Fertilizers were available. Manpower shortages were overcome. The wheat crop is estimated by the U. S. Department of Agriculture to be the biggest ever produced in that country. How much of it will be available to Italians is a question. Their wheat areas are in the Po valley and to the north, where the country is now infested with the German forces. The winter fruit and nut country is also in the north.

Fish food from the Mediterranean can supply much of the need if fishing experts show the way and equipment is furnished. Italy, surrounded by water, has never developed an extensive fishing industry. Sardines from Sardinian waters and tuna from Sicilian seas have constituted the principal export catch. Much other fish may be taken and the Mediterranean is now safe for activities.

"Agricultural production in Italy during the 1943–44 crop year is not expected to be handicapped by any serious lack of commercial fertilizers," states the U. S. Department of Agriculture in a recent release, "unless the Nazis damage or requisition the output of domestic plants which in recent years have supplied most of the country's nitrogenous fertilizer requirements.

"Adequate phosphate should be available from North Africa. Potash, heretofore supplied almost entirely by Germany, constitutes a very minor part of Italy's annual fertilizer consumption."

The productivity of Italian soil is dependent on commercial fertilizers. The amount used in the past dozen years or so is considerably greater than in previous years. Italy was cut off from North African phosphates for only a short while so that the soil has not been impoverished by war conditions.

SOME QUESTIONS AND COMMENTS
"The Psychology of High School Physics"

PAUL F. BRANDWEIN
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Thomas Morse Barger, in a recent issue of SCHOOL SCIENCE AND MATHEMATICS[1] wrote briefly on "The Psychology of High School Physics" and in so doing, made several statements which are worthy of question and comment. It is best to quote directly from the article; in each case these quotations refer to high school physics.

"*Attitudes.*—We see evidence that at least the following seven attitudes are developed: 1. Interest in the subject and in other subjects. 2. Interest in phenomena about the pupil. 3. A judicial attitude towards the work. 4. Attention. 5. Exactness in speaking, thinking, etc. 6. Inquiry. 7. Work, or study."

Again, "Physics also develops a *right attitude towards other subjects* in that it leads the pupils to look for the 'why' of things about them, ... This right attitude carries over to things, persons, and environment in general."

Barger's statement "We see evidence . . ." is interesting. What is the evidence and where is it to be found?

With regard to the development of the "right attitude towards other subjects" and as to the stated fact that "this right attitude carries over to things, persons and environment in general," it would again be interesting to have the facts, the evidence, or reliable observation.

Many other statements may be questioned but one more may be quoted for purpose of discussion. "*Skills.* It is a question in the minds of many educators whether skills are acquired in any class in school but physics at least develops four skills: 1. General school skills. 2. Laboratory skills. 3. Thinking. 4. Study Skills."

In view of the lack of documentation of the paper, it is difficult to understand whether Dr. Barger bases his conclusions on the work of others or on his own investigations. His statements have such import for the outcomes of general education that their significance may not be overlooked.

Perhaps some comments may be made here. There is no doubt that physics as a science deals with accurate statements based

[1] Barger, Thomas Morse, "The Psychology of High School Physics," SCHOOL SCIENCE AND MATHEMATICS, 43: 303–308, 1943.

on detailed investigations, verified and confirmed in many laboratories. Thus the statements "the pressure in a liquid is independent of the shape of the vessel" or "$I=E/R$" or "with the temperature constant, the gas volume varies inversely with the pressure"—can be verified repeatedly and the behaviour of matter under conditions where these statements apply may be accurately predicted. The writer is inclined to think, in view of the lack of evidence, that Dr. Barger's statements do not even remotely approach the order of accuracy of the above statements from the science he teaches.

This writer is increasingly aware of the failure of many teachers of science to bring to their discussions of teaching the same discrimination which they bring to their discussions of the science they teach. It might be imagined that teachers of science, trained as many of them are in the method of arriving at accurate conclusions, would bring these methods to bear on the gathering of data designed to build a science of teaching.

When most laws of science are considered, one is struck by the fact that much data subserves them; often this data is gathered by many different men. On the other hand, it may not be generally true, but it is often true that most papers in the teaching of science are not confirmed by others—or at least, these confirmations are not readily available in print.

The writer feels strongly that even as the methods of science have been successful in science, so they may be successful in a science of teaching. Perhaps new techniques may be necessary. Thus far, however, it has not been shown definitely that the methods of science cannot serve teaching.

The tendency to accept as true what appears to be reasonable is one of the greatest obstacles towards the development of a science of teaching. Much of what Dr. Barger states appears to be reasonable. But at one time the earth was in its reasonable place as the center of the universe. At one time, two balls of equal size and different weight reasonably fell to the earth at different times. The lesson which investigation in science sometimes teaches is that what appears to be reasonable may not be true. So many statements in science pedagogy appear to be reasonable. Are they true?

Is it because we base our teaching mainly on what appears to be reasonable, that today a scientifically minded supervisor can say of very few things—"This teaching method is the best one to use under these conditions; here is the evidence"?

It seems to be clear that each time a disease is conquered, it is conquered as a result of the summation of the innumerable ponderous and apparently unwieldy papers which deal with very minute points and apparently "swat a fly with a sledge hammer." It appears that it is necessary to do so to ascertain the truth—and a fly is certainly dead if it is hit truly with a sledge hammer. Perhaps it is just as necessary to deal minutely with the facts we wish to ascertain in science education. Certainly there is justification in such treatment of the mysteries of pedagogy if we believe the methods of science have been successful.

Perhaps it is time all teachers of science began to gather the tremendous mass of facts necessary to the foundations of a science of teaching—by using the methods of science. Here and there, we find some teachers who are investigating strictly by these methods—and in so doing, may help us to determine whether a science of teaching is possible. The writer's faith is that it is possible and probable.

Professor Barger's Reply

Since the article, "The Psychology of High School Physics," appeared in the April 1943 issue of your journal, I have received commendations, comments upon, and criticisms of it from educators across the country from California to New York. Since Dr. Paul F. Brandwein has seen fit to make his comments in print, possibly I should reply in kind.

The purpose in preparing the article was three-fold. 1. To prepare an article brief enough to be suitable for publication in one issue of an educational journal such as School Science and Mathematics. 2. The hope that teachers of Physics, especially those with little or no practical experience, might realize that there may be such a thing as the psychology of a curriculum subject. 3. To have them plan and organize the presentation of their work so as to realize most fully the possibilities of the psychology of their subject. That it has produced so many reactions from teachers in different parts of the country has surprised and pleased me. My hope is that the effect of the thinking produced will result in better and more effective teaching methods in this and other subjects.

In the article, my endeavor was to hold closely to the psychology and to omit all discussion of the pedagogy of the subject. This is difficult to do, especially for one of long teaching

experience. The psychology of a curriculum subject, to those of us who admit there is such, pertains to the development of the proper attitudes, ideas, physical and mental habits, and skills. The pedagogy of a subject embraces the methods for presenting the subject matter so that the above attitudes, ideas, habits, and skills may be realized. These may be closely related but they are not the same. Such opinions and conclusions as may have appeared are the results of nearly forty years' experience in teaching and supervising the teaching of this subject.

As I see it, Dr. Brandwein has confused pedagogy with psychology and has devoted most of his comments to the pedagogy of science teaching. I can agree heartily with practically all that he says relative to the pedagogy of the science subjects. It would be a wonderful thing if educators would set up appropriate criteria which would be of help to the young teacher of these subjects. If Dr. Brandwein is interested in some of my ideas relative to teaching the physical sciences, I refer him to my articles which appeared in the May 1935 issue of the *Journal of Chemical Education*, the April 1936 issue of SCHOOL SCIENCE AND MATHEMATICS, and the May 1942 issue of the *Journal of Higher Education*.

Respectfully submitted,
THOS. M. BARGER

A NOTE ON "NOTES FROM A MATHEMATICS CLASSROOM"

CECIL B. READ
University of Wichita, Wichita, Kan.

Many readers of SCHOOL SCIENCE AND MATHEMATICS may have overlooked a certain statement in a recent article which, if taken at its face value, would imply the possibility of squaring the circle. In Mr. Nyberg's "Notes from a Mathematics Classroom" (page 455 of the May, 1943 issue) problem 1 reads: Solve $3\frac{1}{7}(x+3)^2=9\pi x^2$. He states, "The bright pupil will notice that $3\frac{1}{7}$ is π. Hence he divides by π." *Marvelous!* If we admit this possibility, we find that the area of a square with side $4\frac{1}{2}$ units is a rational multiple of the area of a circle with diameter three units.

If teachers would remember that $3\frac{1}{7}$, 3.14, 3.1416, etc., are only *approximations* to π, equations like this would not be written. In other words, in the given equation, either $3\frac{1}{7}$ should

appear in both members, or π in both, but not π in one member and $3\frac{1}{7}$ in the other. Actually, the bright student would be one who would expand and solve by formula.

In the same example, we find the comment, "Then he does not square $x+3$, but finds the square root of both members. . . . If he tries to be too brilliant and uses $-3x$ as well as $3x$, then he gets only half credit. . . . This is evidently a problem about areas and the radius cannot be negative." Many teachers will question this statement. Without any further information, it is a problem in pure numbers. Even the presence of π does not necessarily imply area. It might involve probability. Moreover, does the fact that a problem involves areas mean that x *cannot* be negative? Example: a circle passing through the origin has its center on the X-axis and its area is 9π. What is the abscissa of the center? To quote "This is evidently a problem about areas"; presumably x cannot be negative. Why not?

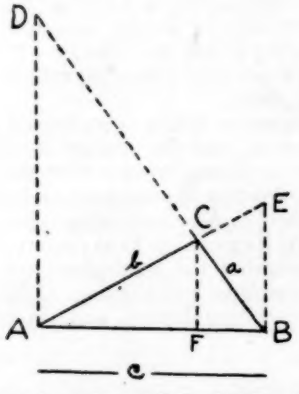
Mr. Nyberg's test is exceptionally good—one should not pick one problem as an example, but unfortunately this seemed a horrible example of what will cause the student trouble later.

A PROOF OF THE THEOREM OF PYTHAGORAS

CORPORAL BERNARD M. GOLDMAN

P.A.A.F., Pampa, Tex.

Let ABC be a triangle having the right angle ACB. Let AD, BE, and FC be perpendicular to AB. (See Figure.) Let $AD=x$, $BE=y$, $FC=z$, and $FB=m$.



From the similar triangles ABC, ABD, AEB, ACF, and BFC

we obtain

$$z/x=m/c;\ z/y=(c-m)/c. \tag{1}$$

Hence, $$z/x+z/y=1. \tag{2}$$

*Thus, $$1/x+1/y=1/z. \tag{3}$$

Since $$x/c=b/a,\ y/c=a/b, \text{ and } z/b=a/c, \tag{4}$$

we find $$x=bc/a,\ y=ac/b, \text{ and } z=ab/c. \tag{5}$$

Substituting the values of x, y, and z of (5) in (3) we obtain

$$a/bc+b/ac=c/ab. \tag{6}$$

Multiplying each side of equation (6) by abc, we obtain

$$a^2+b^2=c^2.$$

* Equation (3) holds for an oblique triangle. Thus, the Theorem of Pythagoras becomes a special case. J. M. K.

WESTERN HEMISPHERE NOW PRODUCING MUCH MATERIAL FORMERLY OBTAINED FROM JAPAN AND OTHER COUNTRIES IN FAR EAST

Thank the Japs for a new inter-American economy resulting from their aggressions in the Far East. Quantities of essential materials formerly imported from Japan and countries now occupied by the Japanese are now being grown or obtained in the Western Hemisphere. Perhaps the Nipponese have unwittingly done the Americas a good turn.

Tropical and semi-tropical America, it is found, can produce much which in pre-war days came principally or wholly from the Far East. Rubber, hemp, quinine, insecticides, spices, vegetable and grass oils are just a few of the products now obtainable in the Americas.

The hevea tree, the principal source of natural rubber, is a native of Brazil, and the nine million acres of rubber plantations in the Far East are forested with lineal offspring of the Brazilian tree. Wild and cultivated hevea trees grow extensively in Brazil; extensive harvesting plans are now in operation. It is being grown now in at least 15 other Latin-American countries, most of which are now gathering rubber from wild hevea and other rubber-producing plants.

The production of improved hemps is increasing rapidly in the United States and in Latin America, and the product is fairly satisfactory. However, some 20,000 acres of abaca, from which Manila hemp is made, is now being grown in the Western Hemisphere, and next year some 125,000 acres will probably be planted. American hemp is being grown in Kentucky.

Native vegetable fibers long used in local communities are now gathered in large quantities throughout the hemisphere and are used for making rope, twine and yarns for bags and bagging. Local industries have been established where none existed before, and probably will remain permanently.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

FORTY-THIRD ANNUAL CONVENTION

FRIDAY AND SATURDAY—NOVEMBER 26 AND 27, 1943

Palmer House, Chicago, Illinois

Friday Morning

General Program 10:00 A.M. *Club Building Dining Room*

Pre-Induction Courses in Science and Mathematics—Merwin M. Peake, Chief, Civilian Pre-Induction Training Branch, Army Service Forces, Washington, D. C.

"Grow" Foods or only "Go" Foods According to the Soil—Professor William A. Albrecht, Chairman, Department of Soils, University of Missouri, Columbia, Missouri

What Air Navigation is Not—Professor Harry C. Carver, Department of Mathematics, University of Michigan, Ann Arbor, Michigan

Friday Noon

Luncheon 12:30 P.M. *Red Lacquer Room*

A Demonstration Lecture—Electromagnetic Radiations—Dr. Luther Gable, Instructor, U. S. Army Signal Corps, 6th Service Command, American Television Laboratories, Chicago, Ill.

Saturday Morning

General Program 9:15 A.M. *Club Building Dining Room*

The Central Association and Cooperative Work on Pre-Induction Courses, Ira C. Davis, University High School, University of Wisconsin, Madison, Wisconsin

The Work of the Chemical Warfare Service—Lt. Colonel William O. Brooks, Chemical Warfare Service, Washington, D. C.

Elementary School Group 10:20 A.M. *Private Dining Room 11*

Can Concepts in Elementary Mathematics be Developed?—Dr. John T. Johnson, Chicago Teachers College, Chicago, Illinois

Discussion from the floor

What Problems has the War Brought to the Administration and Teaching of Elementary Science? How are these Problems being met?—A Panel Discussion—Discussion Leader, Leo Herdeg, Assistant Superintendent in charge of Elementary Schools, Chicago, Illinois, Miss Bertha Parker, Laboratory School, University of Chicago, Chicago, Illinois, Dr. David W. Russell, Director, Avery Coonley School, Downers Grove, Illinois

Discussion from the floor

Junior High School Group 10:20 A.M. *Private Dining Room 9*

A Proposed Science Sequence—William A. Porter, University High School, University of Wisconsin, Madison, Wisconsin

The Mathematics Laboratory—Mary A. Potter, Supervisor, Dept. of Mathematics, Racine, Wisconsin

The Junior High School Science Program—Paul E. Kambly, University High School, University of Iowa, Iowa City, Iowa

Senior High School Group 10:20 A.M. *Club Building Dining Room*

Look Ahead in High School Science—Robert J. Havighurst, Professor of Education, University of Chicago, Chicago, Illinois

Some Aspects of Biological Engineering—James A. Reyniers, Director of Laboratories of Bacteriology, University of Notre Dame, Notre Dame, Indiana

From Theory of Nerve Growth to the Practice of Nerve Repair—Paul A. Weiss, Professor of Zoology, University of Chicago, Chicago, Illinois

Junior College Group 10:20 A.M. *Private Dining Room 18*

The Use of Films as a Teaching Aid—Robert E. Schreiber, Stephens College, Columbia, Missouri

On Editing a Scientific Journal—Glen W. Warner, Wilson Junior College, Chicago, Illinois

Archimedes and Mathematics—Harold Thayer Davis, Northwestern University, Evanston, Illinois

Conservation Group 10:20 A.M. *Private Dining Room 7*

Soil Conservation for Health's Sake—Professor William A. Albrecht, Chairman, Department of Soils, University of Missouri, Columbia, Missouri

Conservation Education—A Panel Discussion

Chairman and Summarizer—F. Olin Capps, Chief, Education Section, Missouri Conservation Commission, Jefferson City, Missouri

Conservation Education for Teachers—O. E. Fink, Curriculum Supervisor, Conservation Education, State Dept. of Education, Columbus, Ohio

Conservation Education for Secondary Schools—Dr. O. D. Frank, University High School, University of Chicago, Chicago, Ill.

Conservation Education for Elementary Schools—Mary Melrose, Supervisor of Elementary Science, Cleveland, Ohio

Friday Afternoon

SECTION MEETINGS

Biology 3:00–5:00 P.M. *Private Dining Room 7*

Biology for the Armed Forces—Professor I. Owen Foster, Indiana University

Election of Officers

The Biology of Aviation—Dr. Louis R. Krasno, Northwestern University, Evanston, Illinois

Life in the Desert Habitat—John Y. Beaty, Wee Thistlebrae Farm

Chemistry 3:00–5:00 P.M. *Private Dining Room 11*

An Experimental Approach to the Generalized Acid—Base Concept—Dr. Herman I. Schlesinger, Dept. of Chemistry, University of Chicago, Chicago, Illinois

Election of Officers

Some Problems in Tin Conservation—Dr. R. W. Pilcher, Assistant Director of Research, American Can Company, Maywood, Illinois

High School Chemistry, A Master Teacher (Frank B. Wade), Four Decades of Time, and the Results—Walter Geisler, Dept. of Chemistry, Shortridge High School, Indianapolis, Indiana

Elementary Mathematics 3:00–5:00 P.M. *Club Building Dining Room*

A New Approach to Teaching Arithmetic in the Upper Grades—Lawrence Casey, Montefiore School, Chicago, Illinois

Election of Officers

The Teaching of Quantitative Thinking, A Demonstration under the

direction of H. O. Gilett, Principal, University Elementary School, Chicago, Illinois

Trends in the Teaching of Arithmetic in the Elementary School—Dr. E. T. McSwain, Associate Professor, Northwestern University, Evanston, Illinois

Elementary Science 3:00–5:00 P.M. *Private Dining Room 9*

A Demonstration Lesson—Mrs. Maxine Berg, University of Chicago Elementary School, Chicago, Illinois

Election of Officers

Science Centered Experiences for Elementary School Children—An Evaluative Description—Dr. Harold G. Shane, State Supervisor, Elementary Curriculum, Columbus, Ohio

Children's Projects in Conservation—Mary Melrose, Supervisor of Elementary Science, Cleveland, Ohio

General Science 3:00–5:00 P.M. *Private Dining Room 8*

Methods and Devices used in my Teaching at Montefiore Special School—Mary Gillies, Montefiore School, Chicago, Illinois

Election of Officers

Functional Diseases in Relation to Human Individualities—Dr. S. W. Becker, Clinical Professor of Dermatology, University of Chicago, Chicago, Illinois

Geography 3:00–5:00 P.M. *Private Dining Room 4*

Teaching Geography in the Modern World—Edith Parker, University of Chicago, Chicago, Illinois

Election of Officers

Demonstration Lesson—Monica H. Kusch, Washington Junior High School, Chicago Heights, Illinois

Panel Discussion—Dr. Alice Foster, University of Chicago, Chicago, Illinois, Leader; Villa B. Smith, John Hay High School, Cleveland, Ohio; Ruth Mikesell, DePaul University, Chicago, Illinois; Superintendent L. Klitzke, Somonauk, Illinois; Dr. A. H. Meyer, Valparaiso University, Valparaiso, Indiana

A New Map Projection—Professor W. G. Gingery, Butler University, Indianapolis, Indiana

Mathematics 3:00–5:00 P.M. *Private Dining Room 18*

Air Navigation and the Secondary Schools—Professor Harry C. Carver, Dept. of Mathematics, University of Michigan, Ann Arbor, Michigan

Election of Officers

The Philosophy of Technical Mathematics—Harry M. Keal, Head of Mathematics Department, Cass Technical High School, Detroit, Mich.

Physics 3:00–5:00 P.M. *Private Dining Room 14*

Problems in Physics for Pre-Induction Courses—Dr. Lester I. Bockstahler, Physics Dept. Northwestern University, Evanston, Ill.

Election of Officers

The Educational Use of Soap Bubbles—Demonstration Tricks for the Physics Classroom—Eiffel G. Plasterer, Physics Dept., High School. Huntington, Indiana

Radar—Dr. Luther Gable, Instructor, U. S. Army Signal Corps Classes in Pre-Radar and Electronics, American Television Laboratories, Chicago, Illinois

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1821. *Helen M. Scott, Baltimore, Md.*

1825. *Proposed by Myrtie Hyatt, Newburg, N. Y.*

If $a:b=b:c$, show that

$$\frac{a^2-b^2+c^2}{a^{-2}-b^{-2}+c^{-2}}=b^4.$$

Solution by Helen M. Scott, Baltimore, Md.

Since $b^2=ac$, it follows that

$$\frac{a^2-b^2+c^2}{\frac{1}{a^2}-\frac{1}{b^2}+\frac{1}{c^2}}=\frac{a^2-ac+c^2}{\frac{c^2-ac+a^2}{a^2c^2}}=a^2c^2=b^4.$$

Solutions were also offered by David Rappaport, Chicago, Julius J. Brandstatter, Los Angeles, Hugo Brandt, Chicago, Mr. and Mrs. W. R. Warne, Fayette, Mo., M. Kirk, West Chester, Pa., and Aaron Buchman, Buffalo, N. Y.

1826. *Proposed by Martyn Summerbell, Lewiston, Maine.*

If

$$\frac{a+b}{1-ab}+\frac{c+d}{1-cd}=0.$$

Prove

$$(a+b+c+d)=abcd\left(\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}\right).$$

Solution offered by William G. Hessler, Batesville, Indiana

$$\frac{a+b}{1-ab}=-\frac{c+d}{1-cd}$$

$$(a+b)(1-cd)=-(c+d)(1-ab)$$

$$a+b-acd-bcd=-c-d+abc+abd$$

$$a+b+c+d=bcd+acd+abd+abc$$

$$a+b+c+d=abcd\left(\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}\right).$$

Solutions were also offered by Hugo Brandt, Chicago, M. Kirk, West Chester, Pa., David Rappoport, Chicago and Helen M. Scott, Baltimore, Md.

1827. *Proposed by Hugo Brandt, Chicago, Ill.*

Given a line $x=-t$ and a point $A(t, 0)$, to find the locus of all points including $(0, 0)$ for which the squares of the distances from A are proportional to their distances from the line.

Solution by Aaron Buchman, Buffalo, N. Y.

Let $P(x, y)$ be on the required locus.

Then from the given conditions for the locus,

$$\frac{(x-t)^2+y^2}{x+t}=k. \tag{1}$$

Since the locus passes through $(0, 0)$, let $x=y=0$ in (1), and

$$k=t. \tag{2}$$

Replace (2) in (1), simplify, and $(x-3t/2)^2+y^2=(3t/2)^2$, which is a circle with center $C(3t/2, 0)$ and radius $3t/2$.

Solutions were also offered by M. Kirk, West Chester, Pa., and the proposer.

1828. *Proposed by Benjamin Carpenter, Lake Forest, Ill.*

For triangle ABC, prove:

$$\frac{2\sin A\sin B\sin C}{(\sin A+\sin B+\sin C)^2}=\tan\frac{A}{2}\tan\frac{B}{2}\tan\frac{C}{2}.$$

Solution by Alan Wayne, Flushing, L. I., N. Y.

$$\frac{2\sin A\sin B\sin C}{(\sin A+\sin B+\sin C)^2}=\frac{16\sin\frac{A}{2}\cos\frac{A}{2}\sin\frac{B}{2}\cos\frac{B}{2}\sin\frac{C}{2}\cos\frac{C}{2}}{(4\cos\frac{1}{2}A\cos\frac{1}{2}B\cos\frac{1}{2}C)^2}$$

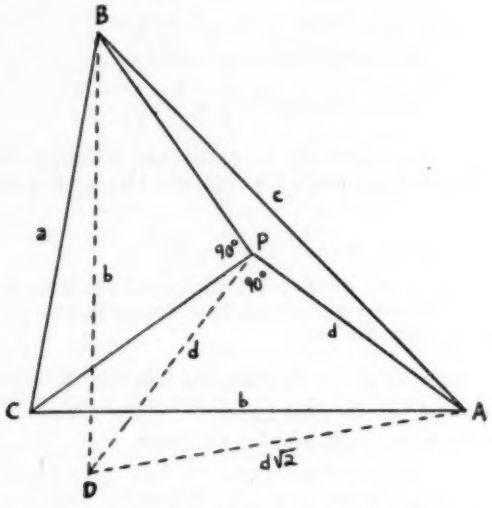
$$\frac{\sin\frac{A}{2}\sin\frac{B}{2}\sin\frac{C}{2}}{\cos\frac{1}{2}A\cos\frac{1}{2}B\cos\frac{1}{2}C}$$

$$=\tan\frac{A}{2}\tan\frac{B}{2}\tan\frac{C}{2}.$$

Solutions were also offered by D. F. Wallace, St. Paul, Minn.; M. Kirk, West Chester, Pa.; Harvey Rubenstein, Brooklyn, N. Y. and the proposer.

1829. *Proposed by Fred Jones, Scott's Corners, N. Y.*

On the side BC, of triangle ABC, as hypotenuse an isosceles right triangle is constructed with P as third vertex and on the same side of BC as A. Prove: $2PA^2 = b^2 + c^2 - 2bc \sin A$.



Solution by Aaron Buchman, Buffalo, N. Y.

Case I: P is within $\triangle ABC$.

Construct $\angle DBP = \angle PCA$ so that PB is *between* BD and BA. Let $BD = CA$. Draw DP and DA. Then $\triangle BDP \cong \triangle CPA$. Thus $DP = PA = d$, and $\angle BPD = \angle CPA$. Therefore $\angle DPA = \angle BPC = 90°$ and

$$DA = d\sqrt{2}. \tag{1}$$

Also

$$\angle DBA = (C - 45°) + (B - 45°) = 90° - A. \tag{2}$$

From the law of cosines,

$$(DA)^2 = (BD)^2 + (BA)^2 - 2(BD)(BA) \cos \angle DBA. \tag{3}$$

Using (1) and (2) in (3), $2d^2 = b^2 + c^2 - 2bc \cos (90° - A)$ or $2d^2 = b^2 + c^2 - 2bc \sin A$.

Case II: P is outside $\triangle ABC$.

Proof is similar to Case I except that BD and BA are taken on the *same* side of PB.

Solutions were also offered by Helen M. Scott, Baltimore, Md.; Mr. & Mrs. W. P. Warne, Fayette, Mo.; M. Kirk, West Chester, Pa.; and Hugo Brandt, Chicago.

1830. No solution has been offered.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

1835, 7. Robert Wilentz, Perth Amboy (N. J.).

1825, 6. H. S., William G. Hessler, Batesville, Ind.

PROBLEMS FOR SOLUTION

1843. *Proposed by Hugo Brandt, Chicago, Illinois.*

If vertex, C, of a parallelogram $ACBD$ is the center of a circle passing through D, and if vertices A and B lie on the radii CAA' and CBB', find the diameter of the circle if $AA'=a=4$, $BB'=b=5$ and the diagonal $AB=d=7$.

1844. *Proposed by Hugo Brandt, Chicago, Illinois.*

In an infinite series whose general term is

$$a_n=\frac{2n+1}{n^2(n+1)^2},$$

let S_k be the sum of the first k terms and $S_{k'}$ be the sum of the remaining terms. If the difference of the squares of S_k and $S_{k'}$ equals $.98(S_k+S_{k'})$, find k.

1845. *Proposed by B. M. Etrinne, Montreal, Canada.*

If a trapezoid be inscribed in a circle, the center of the circle, two opposite vertices of the trapezoid and the point of intersection of the non-parallel sides produced are concyclic.

1846. *Proposed by Harvey Rubinstein, Brooklyn, New York.*

Resolve into factors $a^3+b^3+c^3-3abc$.

1847. *Proposed by Clyde A. Bridger, Salt Lake City, Utah.*

If a, b, c are roots of $x^3+px^2+r=0$, find the value of Σa^4 in terms of p, q, and r.

1848. *Proposed by Clyde A. Bridger, Salt Lake City, Utah.*

A rabbit is now a distance equal to 50 of her own leaps ahead of a fox which is pursuing her. How many leaps will the rabbit take before the fox overtakes her if she takes 5 leaps while the fox takes 4, but 2 of the fox's leaps are equivalent to three of the rabbits. Also how many fox leaps were made?

NATIONAL CENTER FOR PHYSICS PROFESSION PURCHASED IN NEW YORK

A national center for the physics profession will be established in a building just purchased in New York, the American Institute of Physics has announced.

It will serve as the hub of scientific activities in physics which are playing an important part in the war and promise major post-war industrial developments. Rapid growth of the profession in the last 20 years made the move from rented space necessary, it was pointed out.

A campaign is now being conducted among American physicists and friends of physics to finance the project.

BOOKS AND PAMPHLETS RECEIVED

ELECTRICITY, by Charles A. Rinde. Cloth. Pages xii+466. 16×23.5 cm, 1943. Harcourt, Brace and Company, Inc., 383 Madison Avenue, New York, N. Y. Price $1.96.

NAVIGATIONAL TRIGONOMETRY, by Paul R. Rider, *Professor of Mathematics, Washington University*, and Charles A. Hutchinson, *Professor of Engineering Mathematics, University of Colorado.* Cloth. Pages ix+232. 13.5×21.5 cm. 1943. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

ELECTRONIC PHYSICS, by L. Grant Hector, *National Union Radio Corporation;* Herbert S. Lein, *University of Buffalo;* and Clifford E. Scouten, *University of Buffalo.* Cloth. Pages viii+355. 14×21 cm. 1943. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $3.75.

MINERALS, THEIR IDENTIFICATION, USES, AND HOW TO COLLECT THEM, by Herbert S. Zim, and Elizabeth K. Cooper. Cloth. Pages vi+368. 13×20 cm. 1943. Harcourt, Brace and Company, Inc., 383 Madison Avenue, New York, N. Y. Price $3.00.

CLEAR THINKING, AN APPROACH THROUGH PLANE GEOMETRY, by Lieut. Leroy H. Schnell, *U.S.N.R. State Teachers College, Indiana, Pennsylvania (On Military Leave of Absence)* and Mildred Crawford, *Rooseveit School, Michigan State Normal College, Ypsilanti, Mich.* Revised Edition. Cloth. Pages xiv+358. 15×23 cm. 1943. Harper and Brothers, 49 East 33rd Street, New York, N. Y. Price $1.96.

PRACTICAL RADIO COMMUNICATION, by Arthur R. Nilson, *Chief Instructor, Nilson Radio School, New York, N. Y. Lieutenant (Technicist) (Communications) U.S.N.R. (Retired); Member Institute of Radio Engineers,* and J. L. Hornung, *Lieutenant A-V (RS) U.S.N.R.; Member Institute of Radio Engineers; Formerly Radio Instructor, New York University.* Second Edition. Cloth. Pages xxiii+927. 14.5×22.5 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $5.00.

AMERICA AT WORK SERIES: MACHINES FOR AMERICA; POWER FOR AMERICA; WINGS FOR AMERICA, by Marshall Dunn, *Author of "Science and Modern Progress" and "Up to Civilization,"* and Lloyd N. Morrisett, *Professor of Education, University of California, Los Angeles.* Cloth. Machines for America, xii+164 pages, 80 cents; Power for America, xii+164 pages, 80 cents; Wings for America, xii+244 pages, $1.00. 13×20.5 cm. 1943. World Book Company, Yonkers-on-Hudson, New York.

VITALIZED PHYSICS, by Robert H. Carleton, *Head of Department of Science, Summit High School, Summit, New Jersey.* Paper. Pages 378+vi. 12×19 cm. 1943. College Entrance Book Company, 104 Fifth Avenue, New York, N. Y. Price 50 cents.

SIMPLIFIED PHYSICS, by Sidney Aylmer Small, and Charles Ramsey Clark. Cloth. Pages x+428. 12.5×18.5 cm. 1943. E. P. Dutton and Company, Inc., 286–302 Fourth Avenue, New York, N. Y. Price $3.00.

FUNDAMENTALS OF SHOPWORK, A PRE-INDUCTION COURSE AT THE FOUNDATIONAL LEVEL, PREPARED AT THE REQUEST OF THE WAR DEPARTMENT AND THE U. S. OFFICE OF EDUCATION IN CONFORMANCE WITH OFFICIAL PRE-INDUCTION TRAINING COURSE OUTLINE PIT—103. Cloth.

Pages xv+474. 13×19 cm. 1943. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $1.60.

HOW TO PASS A WRITTEN EXAMINATION, by Harry C. McKown, *Author, Lecturer, Editor, School Activities.* Cloth. Pages xi+162. 13.5×20.5 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $1.50.

PLANE TRIGONOMETRY, by Arthur W. Weeks, M.A., *The Phillips Exeter Academy*, and H. Gray Funkhouser, Ph.D., *The Phillips Exeter Academy.* Cloth. Pages viii+193. 15×23 cm. 1943. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $1.75.

SOLID GEOMETRY AND SPHERICAL TRIGONOMETRY, by Henry L. G. Leighton, A.B., A.M., *Instructor in Mathematics, The Phillips Exeter Academy.* Cloth. Pages xix+210. 15×23 cm. 1943. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.20.

PLANE AND SPHERICAL TRIGONOMETRY, by Lyman M. Kells, Ph.D., *Professor of Mathematics;* Willis F. Kern, *Associate Professor of Mathematics;* and James R. Bland, *Associate Professor of Mathematics, All at the United States Naval Academy.* Alternate Edition. Cloth. Pages xvii+400. 15×23 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.00.

PRE-SERVICE COURSE IN MACHINE SCIENCE, by Samuel H. Lebowitz, *Chairman, Science Department, Straubenmüller Textile High School, New York City.* Cloth. Pages vi+440. 13.5×21.5 cm. 1943. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.96.

TEXTBOOK OF QUANTITATIVE INORGANIC ANALYSIS, by I. M. Kolthoff, Ph.D., *Professor of Analytical Chemistry, University of Minnesota*, and E. B. Sandell, Ph.D., *Assistant Professor of Analytical Chemistry, University of Minnesota.* Revised Edition. Cloth. Pages xvii+794. 13.5×21.5 cm. 1943. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.50.

HEAT AND THERMODYNAMICS, by Mark W. Zemansky, Ph.D., *Associate Professor of Physics, College of the City of New York.* Second Edition. Cloth. Pages xiv+390. 14.5×22.5 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $4.00.

ELEMENTARY QUALITATIVE ANALYSIS, by Bruce E. Hartsuch, *Associate Professor of Chemistry, Michigan State College.* Paper. Pages viii+274. 19×26.5 cm. 1943. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.75.

PRE-INDUCTION TRAINING IN VOCATIONAL SCHOOLS, VOCATIONAL DEPARTMENTS AND TRADE SCHOOLS. Paper. 28 pages. 14.5×23.5 cm. 1943. Prepared Jointly by the War Department and the U. S. Office of Education, Vocational Division. Washington, D. C.

SHORT CUTS TO INFORMATION (TIME SAVERS FOR TEACHERS, LIBRARIANS AND ALL WHO MUST FIND THE ANSWERS), by Zaidee Brown. Reprinted from *The Library Key*, Fifth Edition, Revised. 28 pages. 17×25.5 cm. 1943. The H. W. Wilson Company, 950 University Avenue, New York 52, N. Y. Price per copy 25 cents, additional copies in the same order 10 cents.

SOME EARLY EFFECTS OF THE WAR UPON PUBLIC SCHOOLS, by Emory M. Foster, *Chief, Division of Statistics* and Benjamin W. Frazier, *Senior*

Specialist in Teacher Training. Circular No. 218. 13 pages. 20.5×27 cm. 1943. Federal Security Agency, U. S. Office of Education, Washington, D. C.

AN ANNOTATED LIST OF INEXPENSIVE PUBLICATIONS ON NORTH AFRICA AND THE MIDDLE AND NEAR EAST, by Ruth A. Gray, *U. S. Office of Education Library.* Paper. 9 pages. 20.5×26.5 cm. 1943. Federal Security Agency, U. S. Office of Education, Washington, D. C.

SCIENCE AND THE WAR, A SYMPOSIUM PRESENTED AT THE SEVENTY-FIFTH ANNIVERSARY MEETING OF THE KANSAS ACADEMY OF SCIENCE, LAWRENCE, KANSAS, APRIL 10, 1943. Paper. 47 pages. 15.5×23 cm.

PRE-INDUCTION VOCATIONAL TRAINING IN MACHINE SHOP PRACTICE. Paper Pages iii+10. 14.5×23 cm. PRE-INDUCTION VOCATIONAL TRAINING IN AIRCRAFT MAINTENANCE. Paper. Pages iii+24. 14.5×23 cm. PRE-INDUCTION VOCATIONAL TRAINING IN AUTO MECHANICS. Paper. 111+17. 14.5×23 cm. PRE-INDUCTION VOCATIONAL TRAINING IN ELECTRICAL SIGNAL COMMUNICATION. Paper. 24 pages. 14.5×23 cm. 1943. Prepared Jointly by the War Department and the Vocational Division, U. S. Office of Education, Washington, D. C.

AIRPLANE POWER—WITH SPECIAL REFERENCE TO ENGINES AND ALTITUDES. Paper. 80 pages. 13×21.5 cm. General Motors, Detroit, Mich. Copies Free.

SELECTED TOPICS IN HIGHER MATHEMATICS FOR TEACHERS, published by the Association of Teachers of Mathematics of New York City. Paper. 107 pages. 13×21.5 cm. Max Peters, 200 West 15th Street, New York, N. Y. Price 50 cents.

HANDBOOK OF LIFE INSURANCE, by R. Wilfred Kelsey, *Manager, Department of Information, Institute of Life Insurance,* and Arthur C. Daniels, *Secretary, Institute of Life Insurance.* Paper. 64 pages. 14×21 cm. 1943. Institute of Life Insurance, 60 East 42nd Street, New York, N. Y. Single copies free to School Officials or Teachers. Additional copies for classroom use may be purchased at the rate of 10 cents each for quantities up to 100 and at the rate of 5 cents each for quantities in excess of 100.

RADIO-ELECTRONICS IN EDUCATION. Paper. 48 pages. 21.5×28 cm. Published by Department of Information, Radio Corporation of America 30 Rockefeller Plaza, New York, N. Y.

RADAR. Paper. 20 pages. 18.5×26 cm. Published by Department of Information, Radio Corporation of America, RCA Building, New York, 20, N. Y.

VISUALIZED FRACTIONS, by H. C. Hinojosa. Paper. 8 pages. 21×28 cm. 1943. Published by Helen Clancy Hinojosa, 51 Curtis Lane, Yonkers, N. Y. Price 10 cents.

FLYING AND WEATHER. AUDIO-VISUAL AND TEACHING AIDS, compiled by Dr. Lili Heimers, *Director of the Teaching Aids Service of the Library.* Paper. Pages viii+13. 21×28 cm. 1942. New Jersey State Teachers College, Visual Aids Service, Upper Montclair, N. J. Price 50 cents. Remittance must accompany order.

SCIENCE. AUDIO-VISUAL AND TEACHING AIDS, compiled by George E. Flimlin, M.A. (*High School, North Arlington, New Jersey*). Paper. Pages v+43. 21×28 cm. 1943. New Jersey State Teachers College, Visual Aids

Service, Upper Montclair, N. J. Price 75 cents. Remittance must accompany order.

MATHEMATICS. VISUAL AND TEACHING AIDS, compiled by Dr. E. H. C. Hildebrandt, *Assistant Professor of Mathematics*. Paper. Pages iv+15 cm. 1942. New Jersey State Teachers College, Visual Aids Service, Upper Montclair, N. J. Price 25 cents. Remittance must accompany order.

BOOK REVIEWS

ATOMS, ROCKS AND GALAXIES, by John Stuart Allen, Ph.D., *Assistant Professor of Astronomy and Chairman of Physical Science Survey in Colgate University;* Sidney James French, Ph.D., *Professor of Chemistry in Colgate University;* John Grant Woodruff, Ph.D., *Assistant Professor of Geology in Colgate University;* Clement Long Henshaw, Ph.D., *Assistant Professor of Physics in Colgate University;* and David Woolsey Trainer, Jr., Ph.D., *Assistant Professor of Geology in Colgate University*. Revised Edition. Cloth. Pages x+719. 14×21.5 cm. 1942. Harper and Brothers, 49 East 33rd Street, New York, N. Y. Price $3.75.

This is a textbook which has been under construction and use for more than twelve years at Colgate but the first edition for the public did not appear until 1938. The revised edition came out late last year. The book is composed of two chapters from astronomy, five from geology, ten from physics, six from chemistry, and four again from astronomy. Much of the new material in the revised edition is from the two fields of physics and chemistry. The subject matter has been well selected and is admirably presented. Each chapter is followed by a number of good questions and a short list of excellent books for supplementary reading.

The book is an excellent introduction to the study of physical science. We agree with the authors "that an appreciation of the scientific method will grow out of this study of science better than it will come from a formal discussion of scientific method that is divorced from factual material and actual examples." This book deserves a wide adoption and use.

G. W. W.

ATOMS, STARS, AND NEBULAE, by Leo Goldberg (*Now of the McMath-Hulbert Observatory of the University of Michigan*) and Lawrence H. Aller. Cloth. Pages v+323. 14.5×21.5 cm. 1943. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

This is another of the famous set of books edited by Harlow Shapley and Bart J. Bok and designed to acquaint the intelligent layman and beginning student of astronomy with the progress of research and the vast field of the subject. This book attempts to explain to the educated but nontechnical reader the processes going on in the stars. Some of the chapter headings indicate the content. They are Stellar Rainbows, Atoms and Molecules, The Climate in a Stellar Atmosphere, Dwarfs, Giants, and Supergiants, Pulsating Stars, Exploding Stars, etc. The book is highly illustrated with drawings, graphs, spectrograms, photographs from the great observatories, and halftones of the research workers in these great laboratories. However it is a difficult job to explain so much in a small volume. Many ideas, words, and symbols which the authors use can be understood only by one who has done a considerable amount of previous study or who is willing to do it while reading the book. A series of short appendixes gives important constants used and explains some of the physical relationships used.

G. W. W.

RADIO TROUBLESHOOTER'S HANDBOOK, by Alfred A. Ghirardi, Author, *The Radio Physics Course, Modern Radio Servicing, Radio Field Service Data.* Third Revised, Enlarged Edition. Cloth. Pages viii+744. 20.5 ×27.5 cm. 1943. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price $5.00.

Here is the third edition of a practical handbook that has been so useful to radio shop and repair men in previous editions. This book contains all the features that have proved so useful to radio service men in the past and has many new sections which bring it completely up to date. To one in the servicing industry its cost will be paid in the time saved on one job. It assists in locating trouble, speeds up testing, makes difficult jobs easy, saves time and energy.

G. W. W.

HOW MIRACLES ABOUND, by Bertha Stevens, Author of *Child and Universe*, and *Thoreau; Report of the Universe.* Cloth. 200 pages. 15×21 cm. 1941. The John Day Company, Inc., 2 West 45th Street, New York, N. Y. Price $2.50.

Here is an excellent book for the children. It tells about a star, a magnet, a salt crystal, a dewdrop, a lima bean, a petunia, a tree, a snail shell, a goldfish, and the hand. Each chapter is short, but the subject is well introduced and the most important facts about it are told in a most interesting way. A short list of references follows each chapter. It is a number one gift book for all children.

G. W. W.

CLEAR THINKING, Revised Edition, AN APPROACH THROUGH PLANE GEOMETRY by Lieut. Leroy H. Schnell, U.S.N.R., *State Teachers College, Indiana Pennsylvania*, and Mildred Crawford, *Roosevelt School, Michigan State Normal College, Ypsilanti, Michigan.* Colth. 16×23 cm. Pages xiv+358. Harper and Brothers, New York. 1943. Price $1.96.

The teacher who is interested in a text making a gradual approach to formal geometric proof, and hopes to develop logical reasoning can not afford to ignore this text. The teacher who wishes a traditional text will have nothing but condemnation on first inspection, yet one can not help but feel that even in this situation this test would be a valuable addition to the teacher's private library, to say nothing of the school library.

The treatment is definitely one of slow approach with care taken to develop a thorough understanding of important concepts; the arrangement of material attempts to enable the pupil to understand geometry as a whole. One feature worthy of mention is the insertion of frequent drills on fundamental processes of arithmetic and algebra.

There is a large number of exercises, in which an attempt has been made to classify each as to difficulty. Answers to numerical exercises are not furnished. Tables include a short table of squares and square roots, and of trigonometric functions.

Obviously opinions differ, but to a teacher who holds the idea that a text carefully marked by the student is thereby made more valuable, it is very annoying to find at the bottom of a large number of pages a warning such as "Do not write or mark in your book." Again, one objects to this statement made after students have been instructed to measure circumference and diameters of several circles, and compute the ratio, "If you are accurate you will find that the value of this ratio equals 3.141592. . . " (If you get this ratio, you are more than accurate, you must be Superman).

Valuable features are numerous historical references, a vocabulary or list of definitions of geometric terms, and a brief unit on fourth dimentional geometry.

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